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The Bids for the Construction of the Panama Canal.

The most ardent advocates of the lock plan for the trans-Isthmian ship waterway can scarcely justify from their own point of view a smaller estimated cost than \$150,000,000, after allowing for the increased size of locks advocated by the Consulting Board and a provision for attempting to stop dangerous seepage under the Gatun dam, while, as a matter of fact, a reasonable allowance for the vast uncertainties of that plan is likely to swell the expenditures to possibly \$200,000,000 or even more. When it is borne in mind that this great public work must necessarily involve material political considerations, using that term in a broad non-partisan sense, the answer to the advertisements for tenders for constructing the canal carries with it not only great engineering interest but also an interest of even national character.

The number of bidders responding to the request for tenders was four and the percentages bid for the work range from 6.75 to 28. This wide range in the tenders is obviously a measure of the varying estimates of hazard existing in the judgments of the bidders. At first sight it appears remarkable that a bid made upon a percentage basis should afford opportunity for such a range of risk, but an examination of the contract conditions under which the work is to be performed is illuminating. This journal has already expressed full editorial comment upon these conditions, and it is only necessary at this time to indicate the close relation existing between the possible consequences involved in the execution of the contract and the degree of hazard contemplated by at least some of the bidders.

In the first place, the percentage to be received and from which the profit of the contractor is to be derived, is not a percentage of the actual cost of the work, but of a cost estimated by an engineering committee of five members, two only of whom are to be appointed by the contractor. Furthermore, the possible premium or forfeit for early or deferred completion of the contract, respectively, is to be reckoned from the expiration of a period also to be estimated and determined by the same engineering committee. Although there can be no reasonable doubt as to the wisdom of some form of percentage contract for this work, there is abundant room for great uncertainty as to the vicissitudes of the contractor under such general contract conditions as those stated. Under a reasonable and just interpretation and enforcement of those conditions an efficient contractor would suffer no hardships, but it is easy to imagine exigencies which would impose upon him burdens that he might be most anxious to escape; and those exigencies might be intensely aggravated by changing phases of a Federal administration or by the changing from one technical administration to another. While, therefore, a range of bids from the lowest to the highest of more than four times is certainly extraordinary, the circumstances attending the award of this great contract are of such a character as to explain it fully.

It is probably reasonable to admit that parties qualified to bid for this work are entitled to name what they consider a reasonable compensation for themselves. At the same time, if there were ever circumstances under which the award of a contract ought to be made with a view to the best interests of the public, regardless of the lowest bid, this is pre-eminently such a case. The Isthmian Canal Commission owes it to the Government to make the award of this work irrespective of the principle of the cheapest construction, no matter what the bond may be or how thoroughly it may imagine the Government's interests to be safe-guarded by the terms of the contract. If the lowest bidder can show that his qualifications of plant and methods, previous experience and financial condition are such as to afford a certain warrant of his capacity to perform the work satisfactorily, he is assuredly entitled to receive the contract, but not otherwise. It is a question on the face of the bids whether so small a percentage as 6.75 is large enough even from the Commission's point of view to justify the residue of hazard, so to speak, under a form of contract designed to eliminate as much uncertainty as possible. It is not uncommon practice for contractors to receive as much as fifteen per cent. of the actual cost of work with practically no hazard at all. This obviously applies in general to small contracts compared to that under consideration, but in this case, unfortunately, the risks, as far as they exist, are at least in proportion to the magnitude of the work to be done. In fact, there

are some risks not at first apparent which might lead to grave complications and affect most seriously a contractor working on a margin little greater than many broker's commissions. It may easily happen that a percentage more nearly that ordinarily received by contractors would in the end be materially more economical for the Government.

Apparently it is supposed by some of the bidders that negro laborers from the Southern States may be advantageously taken to the Isthmus to work on the construction of the canal. This idea is likely to lead to the serious disappointment of any contractor who attempts to put it into execution. Undoubtedly negro laborers from the Southern States would endure physical exertion to a greater extent than white laborers taken from those States, but no negro laborer even can sustain daily labor on the Isthmus of Panama without tropical acclimatization. It is a safe general proposition that no day laborers bred in any part of the United States can be depended upon to perform daily labor in the tropical climate of the Isthmus. It is highly probable that the Asiatic coolie will play his proper part in the labor forces of the Isthmus before the canal is completed.

There is at least one effective and gratifying feature of the Panama Canal contract about to be awarded, and that is the fact that it is equally well adapted (and with greater simplicity) to the construction of a sea-level canal as to that called for by the lock plan. Judging from reports regarding the situation on the Isthmus, of a more or less serious character, this may prove to be a most useful and simplifying feature of the instrument.

Roads for Motor Vehicles.

Every engineer who is interested in road making has been watching with keen interest the work of the last year or two in the adaptation of roadbeds for motor traffic. Truth to tell the situation is rather serious for all parties concerned. The roads of to-day have been designed with reference to the traffic ordinarily met, that is for rather slow-moving vehicles with metallic tires. Prior to the coming of the motor car the only rubber tires used were on vehicles relatively very light, which formed only an inconsequential part of the total traffic. Heavy teams are, of course, hard upon a road, cutting it in time into ruts, but they do not tear up and throw away the surface material as do the wide pneumatic tires of a fast-running motor car. The effect of these on macadam and similar road surfaces intended to stand rather heavy ordinary wear is peculiarly severe. On country roads, unless the surface is dry, motor cars seem to produce less wear than ordinary vehicles, a fact often forgotten by the local Solons. On a dry surface without binding material of any coherent kind the trouble begins and rapidly goes from bad to worse. Now the questions raised by these conditions are various. The motor car, whatever ups and downs there may be in its career, has come to stay as a useful member of progressive society. Therefore provision must in some manner be made for it and for the high-speed traffic it has initiated. How to accomplish this is a very difficult matter to decide. In the long run a good roads campaign on a very large scale will have to be inaugurated. This, however, takes much time and money and a tedious campaign of education. So long as the motor car is in a very small minority as regards total share in the traffic, the general public will rather hesitate at changing for its benefit the types of roadbed suitable for ordinary vehicles.

Nevertheless it is fair and desirable from every

point of view to keep road construction on the move forward and the stimulus is already felt. One of its interesting places is the proposition for building automobile turnpikes at private expense, with grades and surfacing adapted for high-speed cars; to build, in other words, a more or less complete system of roads strictly for modern conditions. It is curious to note that the specialized automobile way is suggested in some detail in one of Mr. H. G. Wells' clever stories published several years since, long before the topic attained general importance. It is also a curious coincidence that the first serious attempt to embody this suggestion in an actual thoroughfare should hail from Boston, which was stigmatized by Mr. Wells on a recent visit as a species of intellectual graveyard. The proposition for an automobile boulevard between New York and Boston, to which references have been plentiful recently, is certainly an interesting outgrowth of the good roads discussion. The plan proposed is for a nearly straight and level turnpike over a private right of way without grade crossings or other obstruction—a double roadway wide enough for four cars to run abreast in each direction and well surfaced enough to permit the highest available speeds. In this respect it does not go quite as far as Mr. Wells' proposal of a duplex roadway, one part being reserved for vehicles at a hundred miles an hour or so, the other to suit more conservative speeds. The road proposed would be built strictly by private enterprise and would receive its income from tolls, say of 3 to 5 cents per mile per vehicle, the total cost being estimated at somewhere about \$12,000,000.

Daring as the project seems at first thought propositions apparently far more hazardous were carried out in the early days of steam railroad-ing and have been justified by the results. A new method of traveling always involves unknown possibilities, and it is a rash prophet who attempts to set limitations to progress. One who has faith in the future of the automobile must be inclined to the opinion that such an enterprise would eventually justify itself, and it could undoubtedly be carried out to-day at much less formidable expense than years hence, when rights-of-way would be far more costly than now. The status of this particular proposition is, however, only an incident to the main question, as to the practicability of carrying out a somewhat elaborate system of special roads suited to the needs of motoring. Motoring as an amusement can and does make way for itself on all roads. Horses gradually become familiar with the cars, which no animal can be blamed for fearing at first sight, and as time goes on the mutual courtesies of the road will be generally respected. But the automobile as a serious means of transportation at speeds vastly in excess of those previously possible with private vehicles is another matter. No now established system of highways can accommodate by reason of limitations of width, surface, grades and curves, vehicles to be regularly operated say at 50 miles per hour and upwards over long distances. There is a vast difference between letting out a car to such speed on a casual bit of good and clear road, and traveling safely and comfortably at such speed from place to place. It is this larger function of the motor car that now rises for serious consideration. It looks much as if provision would soon have to be made for at least a limited amount of specially graded and surfaced road especially for motor cars, to which the restrictions absolutely necessary in roads for mixed traffic should not apply.

Special roads for limited classes of traffic are already not unfamiliar in modern park systems, which are generally provided with bridle paths. But one must admit that the extraordinary requirements of automobile ways put them out of

that class, and for the present it seems necessary to depend mainly on improved roads for common use of all vehicles, save, perhaps, for special boulevards which might as fairly be set apart for automobiles as others have been for horse-drawn vehicles. Of the many attempts at improved road building, none have been altogether successful. Macadam in its ordinary form is rapidly destroyed by automobiles and the surface must be protected against very expensive repairs, and, what is equally important, those living on the streets must be protected from the dust nuisance. In built-up streets this is extremely serious, undoubtedly causing considerable damage to real estate values. Happily any successful provision for protecting the surface cuts down the dust. Of the various measures tried with macadam, the tar surface seems to give the best result. Thoroughly applied with due care to ensure penetration and with proper rolling afterwards, it forms a surface that is smooth, durable and somewhat resilient, checks dust formation and is fairly cheap. The petroleum treatment has given on macadam less favorable effects, besides being rather offensive to the general public. Of the various other schemes tried, none seems to be more useful than the two mentioned, under American conditions. The petroleum is undeniably valuable under some conditions, especially where the dust is ordinarily deep. It would seem likely that further work along this line of extra surfacing would give considerable relief on the much-used roads near large cities. Further out the only reasonable chance for good automobile roads suited to high speeds would seem to lie in State action, or possibly in aid from private enterprise as regards the longer lines between city and city.

Cost-Plus-Premium Contracts.

Under some circumstances there can be little question that the average contract may become merely an agreement to differ. A man engaged in most lines of business is a buyer and seller of goods of some sort. The quality and quantity of these goods can be established without much difficulty, and if a chop of tea, for example, does not come up to the sample the remedy is self-evident. When a merchant determines to put up a building he generally goes about the undertaking in much the same way that he buys goods; overlooking the fact that he is embarking on a venture he knows nothing about. He relies on the fact that his professional adviser is to "superintend" the construction, and accordingly shops around for the lowest bid he can get for the work.

He generally takes good care to confine the bidding to firms in good standing, and consequently his lump sum bids are from parties which intend to give him the full value of his money. When the plans are well drawn and the specifications clear and comprehensive, the work is usually well done. For various reasons, however, the lump sum tender may prove too low to cover the cost of the work, let alone yielding a profit, and the owner then faces the problem of securing what he wishes at an unfair price, however legal it may be. It is true that many contractors carry out work at a loss without skimping it in material or workmanship, but it is also very sure that there are others who take advantage of the owner's ignorance and the slackness of the supervision to save a few dollars here and there. The lump sum contract is usually satisfactory when applied to work of a well-known character, where the services rendered will be as well defined as staple merchandise, but as soon as the element of chance enters into the undertaking, such a contract becomes a gamble.

In some classes of construction it is imprac-

ticable to foretell accurately what conditions will be encountered, and for such cases various attempts have been made to draw up contracts which will make the interests of the owner and contractor identical. The most common of these is the cost-plus-percentage contract, in which the owner pays the book-cost of the work and also gives the contractor an agreed percentage of the actual cost as his compensation for directing the construction. A great deal of work has been performed satisfactorily under such agreements, but they have the manifest disadvantage of giving the contractor no incentive to keep the cost down or to hurry the work.

In the last three years the cost-plus-fixed-sum contract has come into vogue, its main superiority over the percentage form being that by limiting the contractor's profit to a definite sum it makes it somewhat advantageous to him to get the work done promptly, while it prevents the owner from believing that the cost of the work is unduly increased to give the contractor a large profit, as is possible under a percentage contract. In some classes of work, both these forms of agreement are better than lump-sum contracts, but neither of them makes the contractor in any way responsible for the accuracy of his estimates. Where the work is of a hazardous nature, it is, of course, undesirable to expect the contractor to estimate closely, and in such cases either form of contract is probably a good one when responsible parties are employed.

Both percentage and lump-sum contracts are often employed to-day for straight-away work, for which lump-sum contracts might also be granted without hesitation to experienced contractors of good standing. For such cases, Messrs. Tucker & Vinton, the concrete specialists, are now offering a new form of contract which makes their interests more nearly identical with those of the owner. This they term a cost-plus-premium contract, and in its essential characteristics it is the same as that proposed by the Isthmian Canal Commission and already used to some extent in the purchase of pumping engines and the building of naval vessels. By this form of agreement the contractor undertakes to complete a piece of work for a definite sum in a definite time, and in addition is to be paid a premium which falls below or rises above a stated amount according as he does worse or better than the stipulated performance, as respects both cost and time.

The advantage claimed for this form of contract to the owner is that he can ascertain under it what the work will cost as closely as under a lump-sum contract. If the work cost less than the estimate, half of the saving he keeps and the other half goes to the contractor; if the work costs more than estimated, half the additional sum is deducted from the contractor's premium. If the work is completed ahead of time, he pays the contractor a certain sum per day of time saved; if it is completed behind time, a corresponding deduction is made from the contractor's premium.

The drawback evident in this form of agreement, if drawn up without a competition, is that by placing the estimated cost and time of the work rather high, the contractor stands to make a very large premium by beating his estimates. This is recognized, however, by the company advocating this form of agreement, and it contemplates offering it in direct competition with lump-sum bids, making its estimated time and cost provisions the basis of comparison with such lump bids and throwing in the variable premium agreement as an indication of its intention to unite its interests as closely as practicable with those of the owner. It is hardly necessary to say that the outcome of this experiment will be awaited with much interest.

The Whole Thing.

It is generally acknowledged in railway circles that Judge T. J. Freeman, general counsel of the Texas & Pacific Railway Co., is very well qualified by experience and temperament to talk to the point on railroad subjects. In a recent address before the Association of Transportation and Car Accounting Officers he made the following statements, which are reproduced here as teaching by inference a moral that is worth more than a moment's consideration: "A few years ago it developed in financial circles that Mr. Hill, of the Great Northern, had performed some remarkable stunts in the matter of economical transportation. I venture the assertion that before Mr. Hill performed these stunts and they became known to the world, he had studied the local situation of his traffic from one end to the other; that he had studied the question of the movement of his local and through traffic; that he had perfected his roadbed; that he had increased the number of his passing points and sidetracks; that he had his equipment in the very best possible condition, both as to cars and motive power, and when all of these conditions had been thoroughly understood and perfected, Mr. Hill pulled off his show, and made a most remarkable exhibition and a most successful one. Shortly after he had made prominent in financial circles these miracles in the matter of transportation, many railroads in the West, Southwest and South thought that they would perform the same stunts. They had gone to the circus and seen how easy it was, and they undertook to do the same thing. They got the tent and the brass band, and the show was pulled off, and gentlemen, if I may be allowed to express an opinion, the only thing that worked was the big horn and the big drum."

To those who are acquainted with the costly mistakes made in following the lead of the Great Northern lines, this statement may seem just a bit cruel. It is hard enough to have to own up to stockholders that one is not a genius, without having the fact noised about publicly. As a general proposition, however, without referring to specific examples, it may be truthfully stated that the railway field recently afforded admirable examples of the necessity of good balance in all parts of the whole thing. When any business enterprise gets as big as a trunk railroad, administered by departments which require for their heads men of exceptional ability, it goes without saying that the man at the head of the whole thing must possess qualifications which are rarely combined in one individual. He must decide how far each department may be advanced so that its progress shall fit properly into the progress of the road as a whole. That this gift of accurate judgment is rare is shown by the numerous unsuccessful attempts to run enormous locomotives and heavy trains over lines not physically ready for the traffic. It is particularly interesting to point to this rare gift of broad comprehension of the railway problem, because this week Mr. J. J. Hill, who certainly is one of those possessing it, has made public some very strong arguments for the construction of far more tracks to handle the transportation business of the country. Although he nowhere says so, it is very likely that one of the reasons for his vigorous statements is his well-known desire to improve the safety of train operation. Without many more tracks, it is out of the question to handle traffic of much greater volume and at any decent speed. Block systems and such things are highly useful where there is track room for traffic; where there is not room, the problem is one that railroad men must discuss behind closed doors.

The history of the times is unquestionably

toward consolidation, for it gives better service at the same or lower rates. But with consolidation comes the need of men able to fill the top places, to govern the whole thing. This is a factor which should be considered in any proposed joining of interests, large or small, and it is because it has not been kept in mind in several recent consolidations of an engineering nature, on a rather small scale, that specific attention is called to it here. About every successful consolidation that this journal has had an opportunity of examining has been successful because there was a man at the head of it big enough to act as an intelligent balance wheel, keeping down the excess energy of one department and furnishing energy to another, so that the whole thing ran smoothly. Unless such a one-man organization is satisfactory to all entering it, the affair had better be dropped, for it is pretty sure to end in a wrangle.

The Salton Sink Troubles and Federal Intervention.

The special message concerning the Salton Sink troubles sent to Congress by the President on Jan. 12 is a document of much importance, in spite of the characteristic exaggeration of statements in it. There can be no question that some federal aid is required if the Imperial valley and the Colorado valley in the southwest corner of the country are to be developed as the great fertility of the soil warrants. There is a very large tract of land there which is reported to be capable of intensive agriculture, provided water can be applied to it when required in proper amounts. According to the President's message there are about 700,000 acres of land as fertile as the Nile valley, which are threatened with permanent ruin unless his suggestions are immediately approved by Congress, and this land, he says, will support a population of at least 350,000 and possibly 500,000 people. It is hardly necessary to point out that what a tract of land may produce when worked by the methods of intensive agriculture, and what it is likely to do under conditions which it reasonable to anticipate during the next twenty-five years are so entirely different that if the President's arguments on this score came from a less distinguished source they would be termed "hot air" by the well-informed farmer. But the fact that the special message contains exaggerations should not delay action by Congress, although that action need not necessarily proceed along the lines indicated.

In order to understand the situation it should be pointed out that a good many years ago a company was formed to exploit the Imperial valley, a great depression below the sea level west of the Colorado River. This company was apparently poorly managed and in order to keep itself going formed various subsidiary companies to conduct restricted classes of business or construction. One of these minor works was the building of water-supply systems taking water from the Colorado River. In the course of this work a breach was made in the banks of the Colorado River on Mexican territory, and this breach was widened and deepened by the escaping water until the whole flow of the river passed through it into the valley instead of going into the Gulf of Lower California. Little by little a lake began to form in the valley, and as the water level rose the Southern Pacific Co. found it necessary to shift its tracks. The land company and its subsidiary branches soon reached the end of its limited resources and applied to the Southern Pacific Co. for assistance. That railway had a large mileage of track at stake and was also interested as a transportation agent in the development of the valley. It accordingly advanced

money to the land company, taking about half its stock as security, and undertook the direction of the work of controlling the river. It has since then spent about \$2,000,000 on this work and is still carrying it on. Attention is specially called to the fact that the Southern Pacific Co. had nothing whatever to do with the cause of the trouble, and its investment in the stock of the land company was doubtless due to its desire to have something to show on its books for the millions it spent in trying to save the valley.

In view of these facts, the President's recommendations appear, on their face, to be extremely ungracious and unfair. He demands that the Southern Pacific Co. complete the temporary closing of the gap through which the water is now coursing. It must be borne in mind that the present gap is a new one, which broke through the banks of the river after the cuts made by the land company had been closed. In addition to being held responsible for repairing trouble for which it and its interests are not remotely responsible, the President asks Congress to demand from the land company, which is the Southern Pacific Co., all its land upon such reasonable terms "as shall protect the interests of the Government and the water users." Not one word is said in the message of any reasonable rights which the Southern Pacific Co. may have as a result of its great expenditures for a work which was in no small measure an act of charity on its part. When the Government has secured all these rights then the whole district is to be made over to the Reclamation Service for development in the usual manner in which its projects are carried out, save in one important respect, namely, Congress is to make a loan for the purpose because the funds of the Service are already tied up in other projects.

This whole plan and the wild claims with which it is urged seem to be wanting in accuracy. There can be no question that the land company should repair at its own expense all damages due to the original breaches made by it in the river banks. This it has already done. There can also be no question that Congress should treat liberally the present work of the Southern Pacific Co., through the land company, in stopping the breach which developed after its legitimate work was done. No other company could complete this work, as the President states in his message, and consequently there is all the more reason for treating it fairly in the matter. But when the breach has been stopped, so that the danger is past, it would be well to go very slowly in the matter of sand-bagging the land company out of its property in order to promote a reclamation service project for which there is no money available under the reclamation law. In some way the President has mixed up a matter of river maintenance which very properly might be turned over to the Corps of Engineers of the Army, who are experienced in such work, with an irrigation project for which any immediate need does not exist, and in order to carry out this compound plan he proposes coolly to appropriate about all the security that the Southern Pacific Co. has to show for a fine piece of unselfish work. It would not be at all strange if that company would do about anything to get out of the muddle, but this is no reason why Congress should not be fair in its action. Congress should, however, send a board of army engineers to the work and find out just what must be done to prevent serious damage through future breaks in the river banks. The irrigation end of the President's recommendations can be dropped out of the present consideration until such a board, made up of the leading unbiased experts on river protection in the country, can inform Congress just what the situation really is and whether all the great dangers that the President enumerates in his message will really exist after the river is controlled.

THE COALING TOWER OF THE NEW WATERSIDE STATION, NEW YORK.

The old Waterside Station of the New York Edison Co., at 38th St. and East River, New York, was completed in 1901, and the demand for electricity so soon exceeded its capacity that it has already been supplemented by an adjacent new station, completed in 1905, of 120,000 h.p. rated or 150,000 h.p. maximum capacity, built on similar lines to the old one, with such modifications as have been suggested by the latest experience and anticipated future requirements. The new 197x330-ft. building is about 150 ft. high and is of steel cage construction with concrete foundations carried down to solid rock. It contains 96 boilers, arranged back to back in four groups of 24 each. These boilers require an average of 150 tons of hard coal per hour, which is delivered to them from steel and concrete bunkers over 80 ft. above the ground.

The six bunkers extend across the full width of the building and alternate with the four smokestacks on the same longitudinal center line, as explained in the detailed description of the building in this journal for Sept. 9, 1905. The three intermediate bunkers each have a single large bin holding 4,675 tons of hard coal without trimming, and two small side bins, each of a capacity of 300 tons of soft coal. The end bunkers each contain 200 tons of soft coal and 2,140 tons of hard coal, giving a total storage capacity of about 18,300 tons of hard coal and 1,300 tons of soft coal. The soft coal is delivered in boat-load lots of about 800 tons each, and the small quantity for which storage is provided is mostly used for experimental purpose or to use mixed with hard coal. If used exclusively it would require about 175 tons per hour to run the generators at their full capacity.

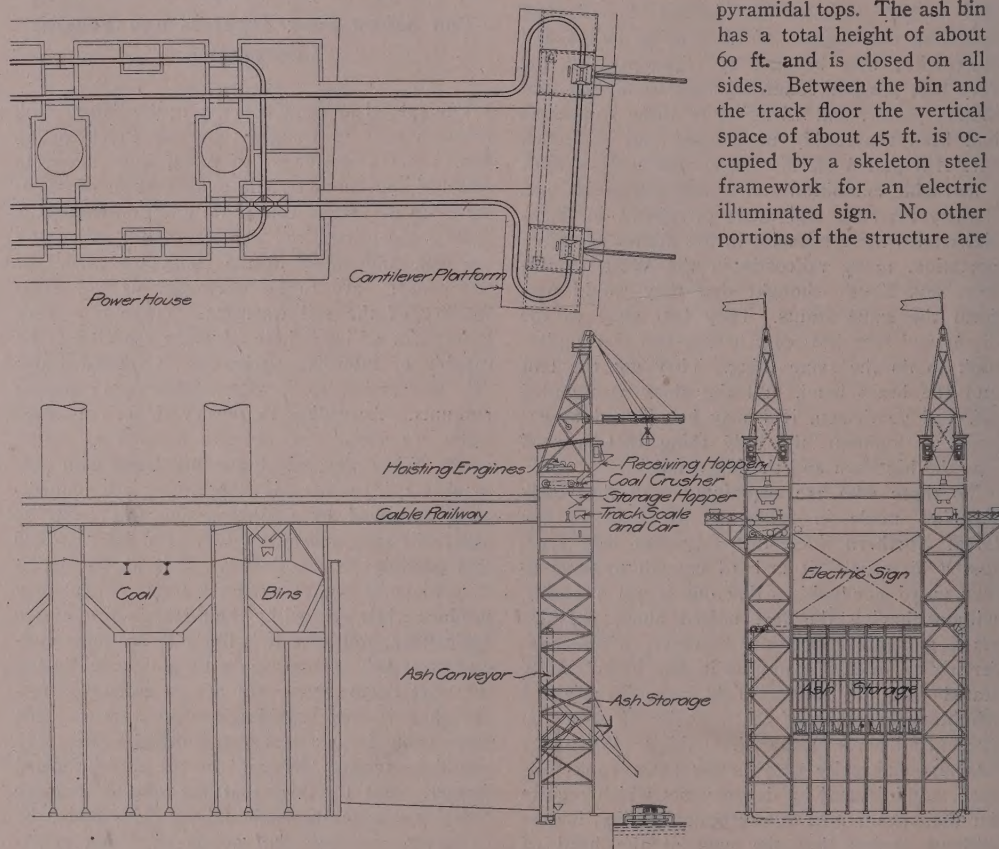
The bunkers are filled by 3-ton automatic dump cars traveling in a continuous circuit on loop tracks that provide four lines parallel to the axis of the building and extend beyond the power house to the top of the coal tower, where they are filled directly from the tower hoppers. The hard coal tracks nearest the center line of the building on both sides of the axis are about 120 ft. above the ground and are carried from the river end of the building to the hoisting tower on a deck plate girder bridge of about 90 ft. span. The soft coal tracks are at a level about 16 ft. below the hard coal tracks and are run across to the outer walls of the building, making a complete circuit independent of the tracks above them. To provide for this arrangement without the necessity of a double deck bridge, both hard and soft coal are delivered at the same level to cars on the tower platform which are run on the same tracks to the building. Here the soft coal cars are dumped into steel storage hoppers of about 10 tons capacity which deliver directly to the distributing cars below. The system is a very simple and efficient one and provides for handling a maximum quantity of 300 tons of hard coal per hour.

General Description.—It was originally intended to unload the coal boats with clam-shell buckets hoisted about 90 ft. and discharged into a receiving hopper, from which the coal would pass through a crusher and be delivered to the horizontal arm of a continuous bucket conveyor system, connecting both sides of the tower and elevating the coal to the distributing tracks, 160 ft. above mean low water. Here the coal would be discharged into an 8-ton hopper and thence into distributing cars on a scale platform. It was finally deemed advisable to avoid the use of conveyors for this purpose and the height of the towers was increased to a total of about 240 ft., enabling the coal to be hoisted by the clam-shell buckets at

one operation to the maximum height. The hoist of about 180 ft. is believed to be the highest of its kind that has yet been attempted, and each of the two 1½-yd. buckets is calculated to make two trips per minute, thus giving a total capacity of 360 tons per hour, a rate which has been considerably exceeded by the single bucket already installed.

The buckets are suspended from a trolley running on a horizontal arm of the stationary jib about 40 ft. long and operated by a Rawson & Morrison hoisting engine with two drums, one for lifting and the other for closing. The bucket is traversed by a trolley engine on the main engine frame and is steadied by a counterweight suspended from the end of the boom.

The buckets discharge into receiving hoppers,



Coal Tower, Ash Bin and Bridge to Power House.

from which the soft coal passes by gravity through a steam-driven crusher to a second storage hopper of about 10 tons capacity, provided with a bottom cut-off valve by which the coal is loaded into W-shaped side dump cars standing on the scale platform and hauled by an endless cable across the bridge to the power house. Hard coal is handled in exactly the same way, except that it is not passed through the crusher. There are two duplicate independent hoists at opposite ends of the tower, and in order to enable the tracks to pass under the crusher, the track floor is extended outside the tower columns and supported on heavy cantilever girders.

The ashes are delivered by chutes under the boilers to dump cars in the basement drawn by General Electric storage battery locomotives and discharging outside the building into a hopper at the foot of the tower. The hopper delivers to a bucket conveyor which elevates the ashes to a height of about 90 ft. and empties them into a 1,000-ton bin below the coal track floor in the tower. The bin is supplied with exhaust steam to heat and dry the wet ashes and prevent them from freezing in cold weather. It has a double

set of very large fixed chutes commanded by vertical sliding gates that enable it to deliver either to barges moored alongside or to wagons on the exterior street.

The tower has a steel framework about 240 ft. high, 110 ft. long and 25 ft. wide, which really consists of two 25x25-ft. twin towers, 240 ft. high and 80 ft. apart on centers, connected by the ash bin at a clear height of 40 ft. above high water and by the track platform at a clear height of 140 ft. above the water. Each of the twin towers is made with four vertical columns about 160 ft. high, divided into seven stories by longitudinal and transverse horizontal struts with X-bracing diagonals in all the panels between them. Above the tops of the vertical posts, the towers have extensions with two vertical and two inclined columns in each.

The track floor is enclosed by a house about 25 ft. in height and 140 ft. long with extensions 20 ft. higher enclosing the bases of each of the pyramidal tops. The ash bin has a total height of about 60 ft. and is closed on all sides. Between the bin and the track floor the vertical space of about 45 ft. is occupied by a skeleton steel framework for an electric illuminated sign. No other portions of the structure are

enclosed, and the skeleton framework in them is completely exposed, as indicated in the general elevation. The longitudinal axis of the tower is at right angles to that of the power house and the tower is seated on the bulkhead wall about 90 ft. in the clear from the power house and separated from it by the exterior street.

Foundations.—Although the power house foundations are carried down to rock, the surface of the latter dips to a depth of about 70 ft. below mean low water under the tower, and as it is covered here with the remains of stone and timber cribs it was very difficult to secure satisfactory foundations for the tower. It was manifestly impossible to build open cofferdams or to prevent the entrance of the water from below, even if it could be excluded from the sides of an excavation.

It was finally decided to construct a pile and concrete foundation substantially corresponding with the standard bulkhead construction adopted by the New York City Department of Docks. This has been done and a very strong and massive substructure was built, as described in The Engineering Record of Jan. 12. This has a tim-

ber grillage about 198 ft. long and 52 ft. wide, supported on thirteen longitudinal rows of piles from $2\frac{1}{2}$ to 3 ft. apart, driven through the old crib work to satisfactory refusal under a 2,000-lb. hammer. The piles were cut off at mean low water and the space around their tops was back-filled with riprap and cobble stones.

Along the river edge the piles are cut off at 14 ft. below mean low water and support a concrete sea wall made with monolithic blocks $10\frac{1}{2}$ ft. wide at the base and faced to below low water level with granite ashlar. Inside this wall the space above the grillage up to grade, about $10\frac{1}{2}$ ft. above low water, is filled with concrete, reinforced in the lower part by two crossed layers of $1\frac{1}{4}$ -in. round steel bars 32 ft. long and 6 in. apart on centers. The column bases are set in pits 5 or 6 ft. below the surface of the concrete and other pits are formed in it to receive part of the machinery required for the tower, thus making some variations from the general dimensions of the foundation above given.

Provisions Against Displacement.—Great care

was exercised in designing and constructing this foundation to prevent as much as possible any danger of displacement after the superstructure was built and the machinery in operation. The great height of the towers, the heavy lateral stresses developed by wind pressure, the vibrations and other stresses due to the machinery and the load from the structure itself and its contents, a maximum of about 4,000 tons, together with the uncertain conditions of the footings and the possibility of their displacement on the irregular rock surface, make possible a tendency for displacement notwithstanding all the efforts to prevent it, and additional precautions have been taken by anchoring the foundation platform and by providing safeguards against injury by any possible movement in the shore end of the bridge which connects the upper part of the tower with the top of the power house.

It was at first proposed to resist possible lateral movement in the bulkhead wall by means of brace piles with their tops inclined towards the shore, but the great depth of water and the ob-

structions in the bottom made this method inadvisable, and it was superseded by a system of horizontal tension members forming the anchorage above mentioned. Each of the three members consisted of twelve $1\frac{1}{4}$ -in. round steel bars about 60 ft. long made in convenient lengths with their ends connected by sleeve nuts. The extremities of the bars are divergent, so that the cross-section of the group is enlarged at both ends like the expansion of cable wires in a cone-socket connection. At the river end, these rods are bedded in the concrete footing above the grillage; at the shore end they are bedded in 10x10x10-ft. concrete piers just below the surface of the ground, which are supported on the old foundations of a gas tank formerly at this site.

Stresses.—In the computations of the tower stresses it was assumed that there might be an outward displacement of the tower footing tending to cause the superstructure to rotate about the feet of the outside columns. The moments thus developed would produce a maximum horizontal tension of 109 tons in the connection of

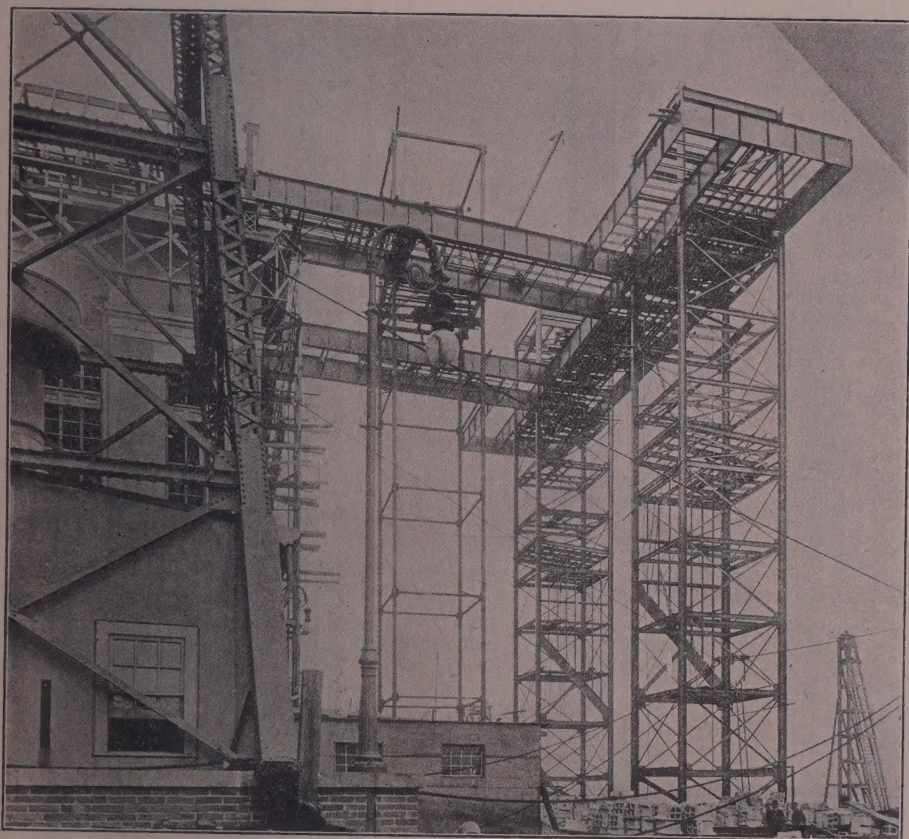
it and prepare in advance for any threatened movement, reference marks have been established on the steelwork and instrumental observations will be taken on them periodically to determine whether any movement actually takes place. So far none has been observed, although some portions of the foundations have already been loaded to nearly the full amount assumed in the computations.

The stresses in the tower have been figured for an assumed wind pressure of 30 lb. per square foot on the enclosed portions and 10 lb. per foot for the area between the track platform and the ash bin, which is covered by the electric sign. The remainder of the structure, that is, the unenclosed skeletons of the towers, have not been figured for any wind pressure. The moments thus calculated are relatively very high on account of the narrow base of the tower, and although they are less than the resistance due to the weight of the tower, thus giving a positive stability, additional security has been provided, as already mentioned, by anchoring the feet of the tower columns. The superstructure is proportioned for maximum unit stresses of 14,000 lb. for the columns and for the shapes in all riveted members and 12,000 lb. for the plate girders, reduced by the formula of the Building Law when in compression.

Columns.—Besides the four main columns in each of the twin towers there are twelve intermediate columns supporting the ash bin, making a total of twenty columns arranged in two longitudinal rows 25 ft. apart. The tower columns are 21 ft. apart and the intermediate columns are 9 ft. apart longitudinally. Their location is indicated by the beam plan of the track floor, which shows the position of the eight tower columns. The intermediate columns terminate below this level, but are all of them located equidistantly in the planes of the girders A-2, A-9, and B-2, B-9. All of the eight main tower columns correspond substantially to B-2, except in the connections for the ash bin, which are located differently on the inside and outside intermediate columns and are omitted on the four end columns. Each column has an I-shaped cross-section and is built in six lengths having milled butt joints spliced with flange cover plates and horizontal connection angles.

The lower sections of the end columns B-2 and B-9, which help support the ash bin, are made of a $16\times\frac{1}{2}$ -in. web plate, four $6\times6\times13/16$ -in. flange angles and six $14\times\frac{5}{8}$ -in. flange cover plates. At the foot of the column, four $8\times6\times\frac{1}{2}$ -in. vertical angles 2 ft. long are riveted to the flange cover plates. They are milled to bear on the bottom extended base plate 3 ft. long and at the top on a 6x8-in. horizontal flange angle which is bored for $2\frac{3}{4}$ -in. anchor bolts. Two more anchor bolts of the same diameter are provided on the transverse center line of the column and take bearing at the same height on similar horizontal angles, riveted to opposite sides of the column web and having the lower flange reinforced by short vertical angles. This provides in all six $2\frac{3}{4}$ -in. anchor bolts about 6 ft. long, engaging at their lower ends reaction beams built into the concrete below the grillage beams.

The connections for transverse horizontal and diagonal tower struts are made with gusset plates shop-riveted to vertical connection angles shop-riveted to the flange cover plates and webs of the columns. These connections are made on two adjacent faces of the columns; on the third face there are connections only for longitudinal struts to the ash-bin columns. These connections are made with short horizontal angles field-riveted to the top and bottom flanges of the eye-shaped struts. The lower angle is shop-riveted to the column web, serving as a shelf to support the strut during erection, and the upper angle is



Lower Part of Tower and Track Platform and Erecting Tower.

each bridge to the power house. This stress was considered too large to be transmitted to the power house, and the bridge connections at this point were designed as expansion bearings, with provisions for their support in the remote possibility of their displacement becoming so great as to pull them off from their original seats.

The assumed overturning moment in the columns would cause a reduction of 70 tons in the total load of each of the main inside columns, an amount which falls well within the maximums of 225 tons wind load and 400 tons dead load for each transverse pair of columns. As the maximum uplift on one column is 150 tons, the tower shows a positive stability even when empty. Nevertheless anchorages are provided for the grillages at the feet of the columns, and it is estimated that the bin can sustain a vertical settlement of 1 in. and a displacement of 12 in. without serious injury to it and without causing any damage to the power house with which it is connected. This amount is considered far in excess of any probable movement, and in order to check

was exercised in designing and constructing this foundation to prevent as much as possible any danger of displacement after the superstructure was built and the machinery in operation. The great height of the towers, the heavy lateral stresses developed by wind pressure, the vibrations and other stresses due to the machinery and the load from the structure itself and its contents, a maximum of about 4,000 tons, together with the uncertain conditions of the footings and the possibility of their displacement on the irregular rock surface, make possible a tendency for displacement notwithstanding all the efforts to prevent it, and additional precautions have been taken by anchoring the foundation platform and by providing safeguards against injury by any possible movement in the shore end of the bridge which connects the upper part of the tower with the top of the power house.

It was at first proposed to resist possible lateral movement in the bulkhead wall by means of brace piles with their tops inclined towards the shore, but the great depth of water and the ob-

field-riveted to the column web after the strut is assembled in position.

The third length of column from the bottom receives the ash-bin connections, and the lower end extends just below the top of the main inclined transverse girder in the floor of the bin, and is field-riveted to the top of the second length through the vertical flange jaw plates and the outstanding legs of the horizontal flange angles. The upper end terminates just above the top of the ash bin and is spliced to the bottom of the fourth length of the column with flange jaw plates and without horizontal web angles. The connection to the inclined girder is made with a short section of the column web which projects about 30 in. beyond the inner flange and is spliced to the girder web with double field-riveted cover plates. The other connections to the column are similar to those of the lower length. Above the ash bin, the upper lengths of the columns correspond to the lower ones, except that the cross-sectional area is diminished.

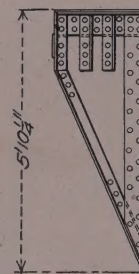
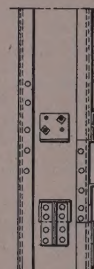
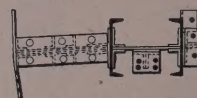
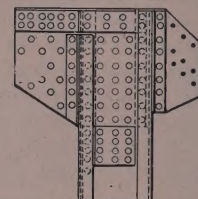
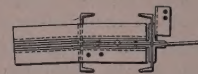
The fifth length reaches to the top of the main track girders and is connected to them with $3\frac{1}{8}$ -in. field rivets through the web plate and the webs of the flange angles. The cross-section is made of a $16 \times \frac{3}{8}$ -in. web plate, four $6 \times 6 \times 13/16$ -in. flange angles and two $14 \times \frac{3}{4}$ -in. flange cover plates.

Column A-3 is typical of the six intermediate columns on the river side of the ash bin and terminates at its roof. Each column is made in three sections, the lower one reaching just above the connection to the inclined bin girder, which,

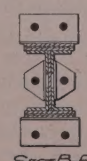
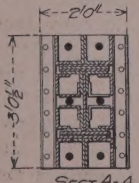
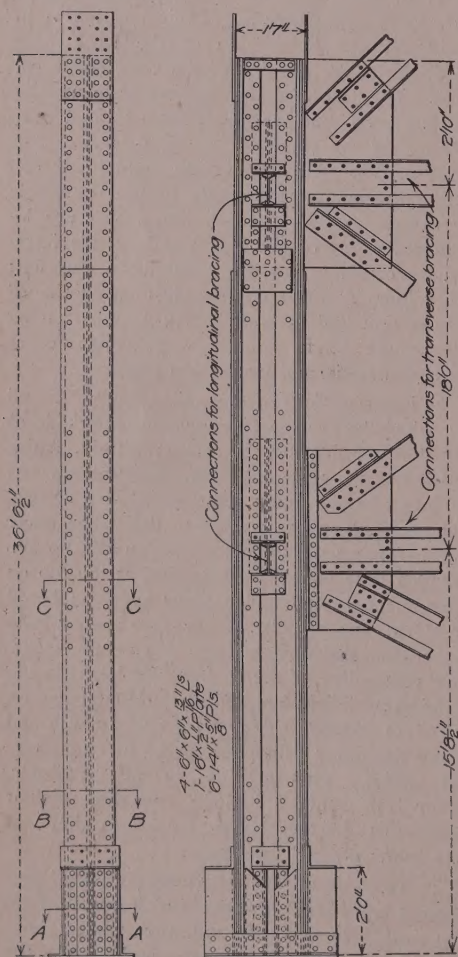
like the corresponding one in the column tower, has a short length of the column web projecting beyond the inner flange of the column to receive splice plates to the girder web and also to afford connections for the transverse and diagonal struts at this point. The column is made of a $16 \times \frac{3}{8}$ -in. web plate and four $6 \times 6 \times \frac{5}{8}$ -in. angles, and has strut connections similar to those described for the tower column. The corresponding columns for the shore side of the ash bin are substantially the same, except that the sectional area is diminished by reducing the thickness of the flange angles to $\frac{1}{2}$ in. that the first length of the column does not reach to the inclined bin girder.

Ash Bin.—The ash bin is of very simple construction with vertical end and side walls and a

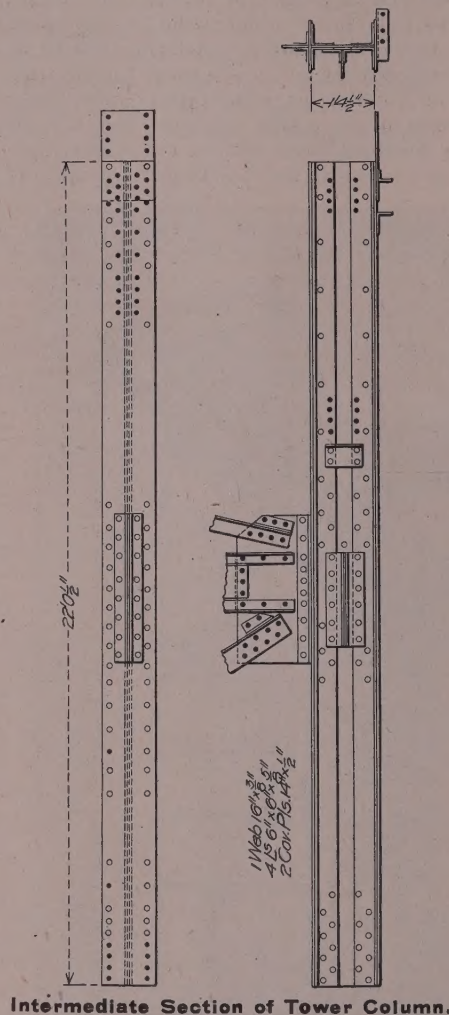
bottom inclined about 45 deg. downward toward the river. The side walls are made with vertical I-beams 3 ft. apart on centers intermediate between the columns, which extend to the tops of the walls and act as girders to resist the outward pressure. The river side is about 50 ft. deep and the vertical beams are 8-in. 18-lb. I-beams framed into several lines of horizontal beams and channels. The shore side of the bin is about 28 ft. high and has 7-in. vertical I-beams framed



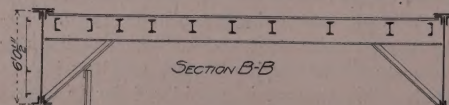
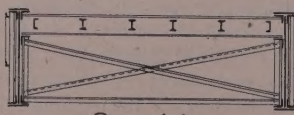
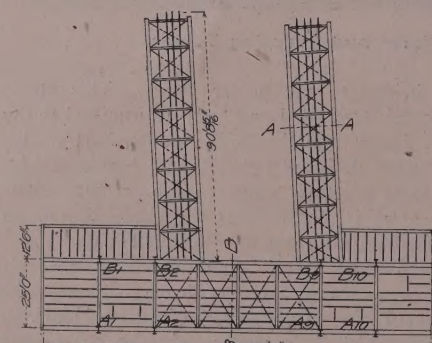
2-15" 33# I-beams
4-5" 33# I-beams
1-17" 33# I-beams



Lower Section of Tower Column; Track Platform and Bridge, and Power House Column Carrying Bridge Girder.



Intermediate Section of Tower Column.



to horizontal 8-in. beams and channels. The end walls have 7-in. vertical I-beams 3 ft. apart framed to heavy transverse I-beam girders.

The inclined floor has six lines of longitudinal 12-in. I-beams spaced in accordance with the varying pressures sustained, from 3 ft. 8 in. apart at the bottom to 5 ft. 6 in. apart at the top. These beams are web-connected to the inclined transverse girders about 35 ft. long over all, 36 in. deep and 9 ft. apart on centers. They are connected to extensions of the column webs with double cover plates at both ends, as already de-

scribed, and are made of pairs of 6x4x3/4-in. flange angles and 7/16-in. web plates. The center points are braced by struts perpendicular to them, reaching to the panel points of the shore side columns. These struts have I-shaped cross-sections with 12x3/8-in. web and four 4x3x5/16-in. angles. The upper ends have cap plates bearing on the flanges of the inclined girders to which they are riveted, and at the lower ends the web is cut short and spliced with double cover plates to the connection plates of the columns while the flange angles are made continuous beyond the ends of the web and engage the connection plate on both sides.

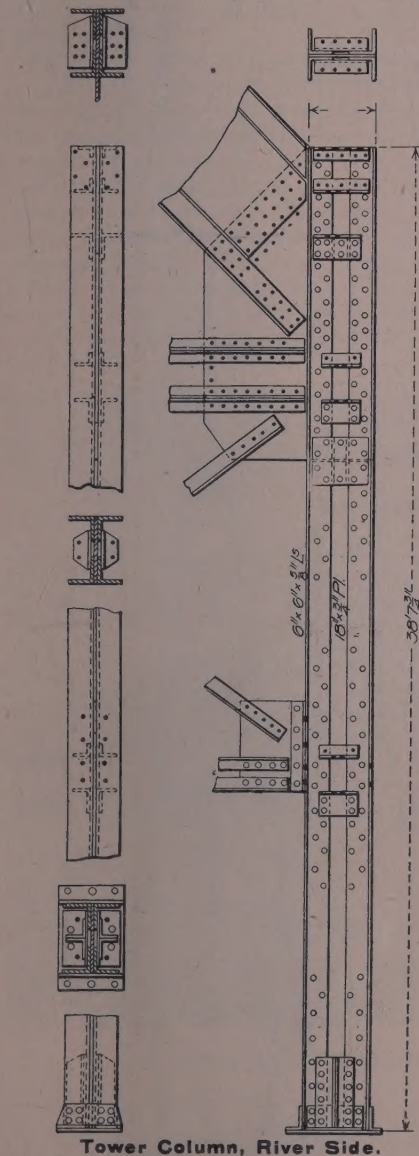
The walls and bottom of the bin are lined with concrete arches of Roebling construction having granolithic finish on the inside surfaces. In each panel of the floor, a scupper nearly 3 ft. square is provided with connection to a fixed rectangular steel chute about 2 ft. square made of 3/4-in. steel plate and 2 1/2 x 2 1/2-in. corner angles. The chutes are about 40 ft. long over all and are steeply inclined so as to insure free discharge of the wet ashes. The lower end projects beyond the river face of the tower and is supported on short struts perpendicular to it, connected to a continuous longitudinal horizontal beam. The bottom of each chute is bent vertical, extends 6 ft. on centers beyond the column and is controlled by a cut-off valve through which it discharges into boats moored alongside the bulk-

head. Similar chutes are provided for discharging the ashes into carts under the tower if necessary.

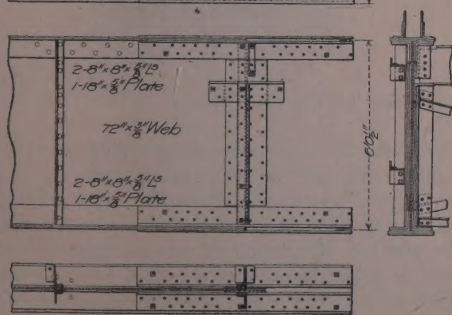
The bin has a flat concrete roof slightly inclined toward the river face and supported on 10-in. longitudinal I-beams 3 ft. apart, seated on the top flanges of 15-in. inclined transverse I-beams connected to the columns 9 ft. apart on centers. Horizontal brackets projecting from the land faces of the columns support two horizontal platforms running from end to end at about the level of the bottom of the bin. The upper platform is 9 ft. wide and the other 10 ft. below it is 6 ft. wide; both of them have wooden floors and afford access to the mechanism for operating the chute valves.

Frame for Sign.—The space between the twin towers above the ash bin and below the track platform is nearly filled in the plane of the river columns by a skeleton framework about 56 ft. long and 35 ft. high, intended to support an electric illuminated sign. This has six equidistant lines of light lattice girders with horizontal webs. They are 3 ft. deep and their flanges are made of single 3x3x1/4-in. angles. The upper and lower girders also form the top and bottom chords of a Pratt truss about 35 ft. deep, divided into panels about 7 1/2 ft. long by pairs of 3x3-in. vertical angles riveted to the opposite flanges of all the horizontal girders. The diagonal members of the truss are similar angles also riveted to the horizontal girders at their intersections.

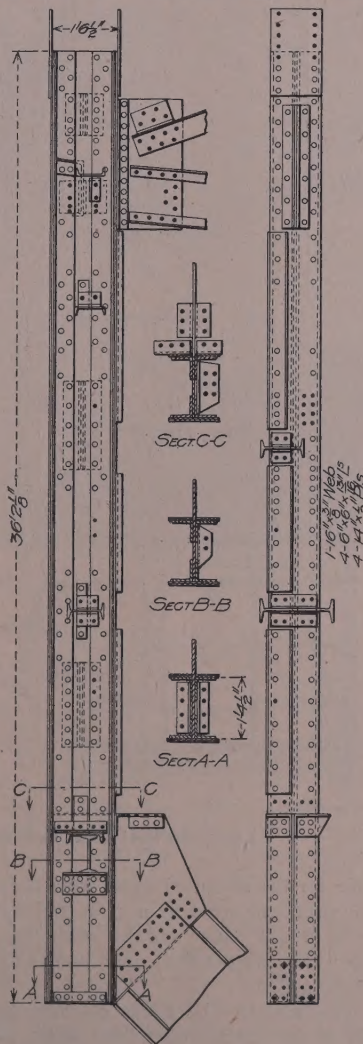
Main Platform.—The main track platform at a clear height of about 139 ft. above datum has two lines of longitudinal plate girders 6 ft. deep and nearly 148 ft. long. These girders are each made in three sections, the middle sections 63 ft. long join the twin towers, and the end sections continuous with them extend across the towers and cantilever 21 ft. 4 in. beyond the centers. These girders are connected by transverse plate girders 27 in. deep in the planes of the tower columns and by intermediate transverse 28-in. I-beams



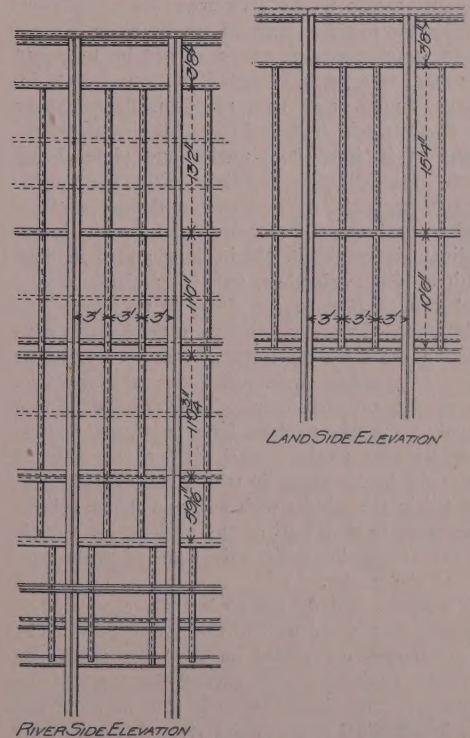
Tower Column, River Side.



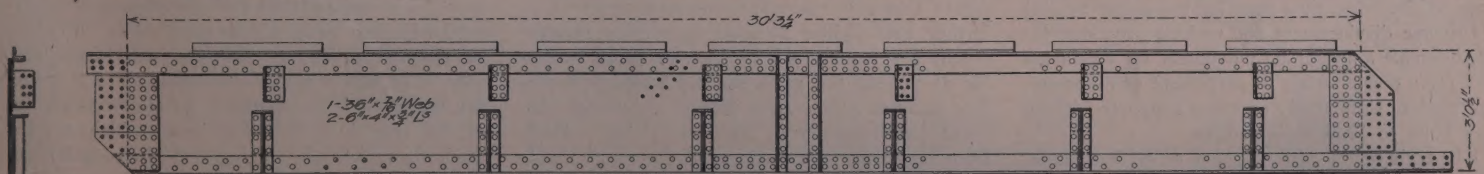
Bridge Girder Splice.



Column on Shore Side of Tower.



Panels of Side Framing in Ash Bin.



Transverse Girder in Ash Pocket in Coaling Tower of New Waterside Station.

from 15 ft. and 16½ ft. apart. The panels between the towers are X-braced with single 1-in. lateral rods. The transverse girders carry longitudinal 9 and 10-in. I-beams on which the 3-in. wooden floor is laid.

This platform is connected to the upper part of the power house by two bridges about 17 ft. wide over all, 90 ft. long and 52½ ft. apart on centers. Each of these bridges has two plate girders web connected at the river end to the longitudinal girders in the tower platform and supported at the other end by the power house columns. They are web-connected to transverse 15-in. I-beams 11½ ft. apart, the panels between which are X-braced with single 3x3-in. lateral angles. The transverse beams carry four lines of 8-in. 18-lb. I-beams on which the track floor is laid. The main girders have angle iron sway bracing in the planes of the transverse beams.

The ends of the main girders in the tower platform are connected by transverse plate girders 6 ft. deep which project 12½ ft. beyond the longitudinal girders on the shore side. Their cantilever extremities carry one end of longitudinal plate girders 6 ft. deep which are web-connected at the opposite end to the bridge girders, thus forming an extension of the main platform beyond the towers which is covered with a plank floor supported on 7-in. transverse I-beams 3 ft. apart, carried by the cantilever girders and by the main longitudinal girders. The overhanging ends of the main girders are knee-braced by angle brackets with curved lower flanges. The girders themselves are sway-braced at panel points with the usual horizontal and diagonal angles.

Both the main platform and the bridges are enclosed by operating houses with angle iron framework and galvanized iron siding and roof, the latter being supported on simple riveted triangular trusses. In the towers the protection is carried up twice as high as in the intermediate portion and is provided with two additional floors, the upper one for the operator and the lower one for the installation of the crushers.

The intermediate sections of the main girders in the track platform are 62 ft. 9¾ in. long and are made of a 72x¾-in. web plate, four 6x6x¾-in. flange angles, and two 14x7½-in. flange cover plates 40 ft. 6 in. long and two of the same dimensions 53 ft. long, both angles and plates being single unspliced pieces. These girders are field-riveted through the outstanding flanges of their end vertical web-stiffener angles to the end longitudinal girders 42 ft. 2¾ in. long and 6 ft. deep with a ¾-in. web plate, 6x6x7½-in. flange angles and two 14x7½-in. cover plates 20 ft. long.

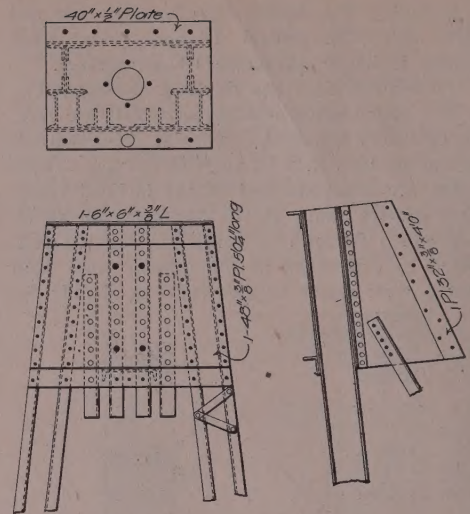
Bridges.—The 90-ft. girders in the bridges connecting the track platform with the power house have a 72x¾-in. web with pairs of 8x8x5½-in. cover plate on each flange. They are divided into panels from 2½ to 8 ft. long by single vertical web stiffener angles. Each girder was shipped from the bridge shops in two equal lengths, field-riveted in the middle with web and flange splices. The webs in each half of the girders, were made in two pieces shop spliced the same as at the center of the girder.

The shore ends of the girders are connected to columns in the end wall of the power house. The lower flanges are seated on solid-web reinforced brackets projecting 2 ft. beyond the faces of the columns. The girder flange is 16½ in. wide and has longitudinal guide angles riveted to each edge to engage the sides of the bracket flange, which is only 8¼ in. wide, thus securing the girder against transverse displacement and making provision for considerable longitudinal movement for expansion and for a displacement or settlement of the tower. The girders slide freely on these supports without any bolts to limit their motion.

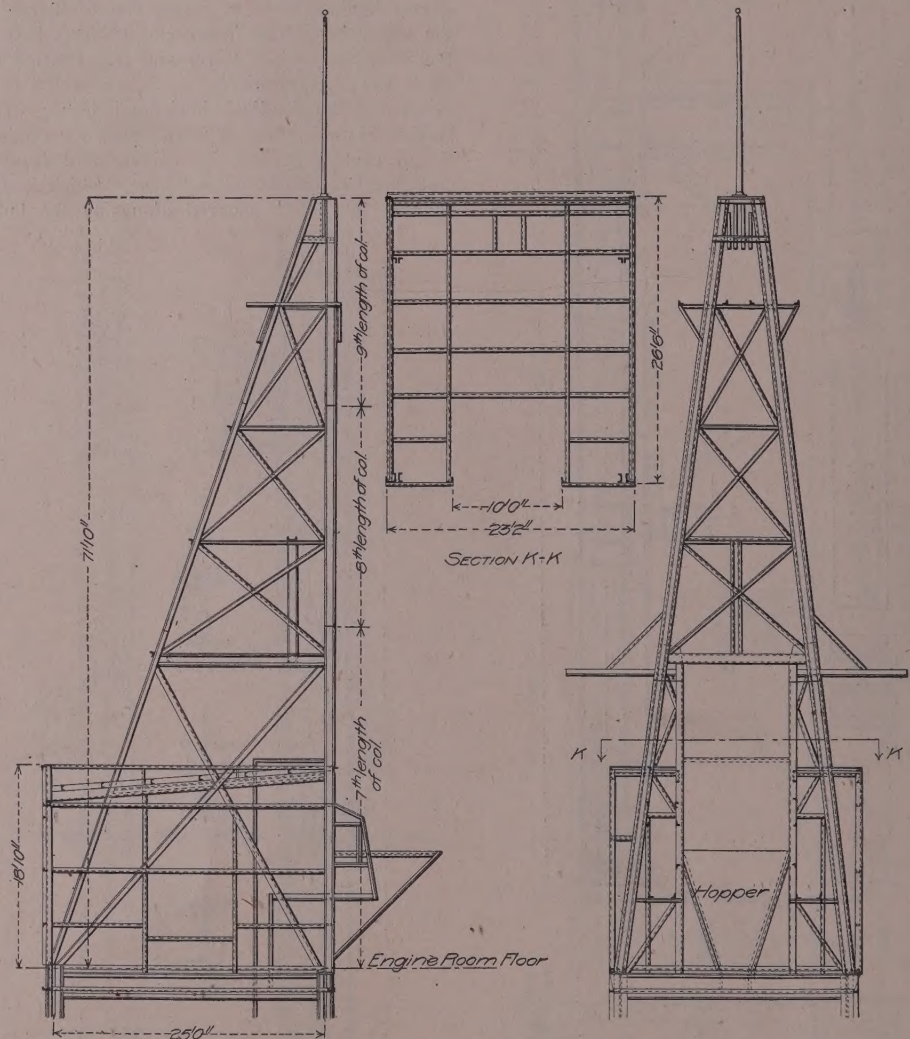
The ends of the upper flanges of girders immediately above these supports are pin-connected to 2-in. vertical rods about 16 ft. long, which have

their upper ends pin-connected to the columns about 22 in. from the center line through reinforced extensions of the column webs. This arrangement is provided to afford support for the girder if the displacement of the tower should be so unexpectedly large as to pull the lower flange entirely free from the supporting bracket, in which case a girder would be suspended from the column in a manner to involve the minimum eccentricity of loading.

As these connections were designed after the construction of the power house, it was not convenient to support the girder concentric with the column without involving more complicated details than was required by the method adopted. The eccentricity of column load was therefore provided for in the column section and the bending moment was cared for by transverse diagonals engaging the sections shown on the column. These columns were originally designed with irregular I-shaped cross sections made of a solid web plate and two pairs of flange angles. In order



Top of Hoisting Tower.



Longitudinal and Transverse Elevations of Top of Tower.

to provide for the increased stress from the girders, they were reinforced by a 15-in. 33-lb. channel riveted to each flange and the connections for the girder seats suspension rods and diagonal braces were added.

Tops of Towers.—The tower columns extend vertically to the engine room floor about 168 ft. above datum and 31 ft. above the track floor. Above this point they are extended about 71 ft. farther with lighter sections converging longitudinally and transversely to form pyramids receiving at the top the guys for the hoisting booms. The columns in the river side of the tower converge longitudinally in vertical planes. Those from the shore side converge both longitudinally and transversely. The arrangement of the panels corresponds substantially to that shown in the

general elevations, but is modified slightly and the details of the bracing are very elaborate on account of the irregularity of the tower and of the necessity of providing for the operation of the hoist and the installation of the machinery.

The principal features of the head bracing, together with the upper part of the tower enclosure, are shown in the front and side elevations. The rear elevation is simpler and the columns are connected by four intermediate cross struts, the panels between which are X-braced with single angles. The tops of the four columns on each tower are united by heavy flange cover plates, as shown in the special detail. The boom which carries the horizontal trolley tracks for the hoisting bucket is made up of pairs of girders carrying a foot walk with hand rails. They are riveted to the tower at

the shore end and are supported at the river end and at two intermediate points by steel rope guys from the top of the tower with sleeve nut adjustments.

The receiving hopper into which the hoisting bucket dumps is about 23 ft. high and of irregular shape. It is supported at the level of the engine room floor by horizontal bearing angles riveted to it and engaging the upper flanges of beams and girders. It is made throughout of 5/16-in. plates from 50 to 69 in. wide, with pairs of 3x3-in. angles at the splices and with single 3x3-in. corner angles and intermediate vertical and horizontal stiffener angles.

Operation.—All of the machinery in the tower is operated by steam and the coal hoisting and conveying requires a total force of only six men. The number required for handling the ashes is variable. The hoisting and lowering of each coal bucket is controlled by one man, and the traversing and dumping of it by a second man, both of whom watch the bucket continuously and do not rely upon signals. In order to provide an unimpeded view of the bucket for the hoisting operator, he is stationed in the projecting bay which has not only side windows, but is provided with a

struts 36 ft. above the highest intermediate struts, which were 8x16-in. timbers projecting beyond the corner posts and supported on 12x12-in. timbers to form the seats for the derrick booms. The bottom of the tower was floored to receive the two double-drum Mundy hoisting engines which operated the wire rope tackles.

The tower was first set between the bridge girders on the shore side of the track platform near its center point, and in this position erected both towers and the track platform, the top of the derrick tower being guyed by two 1 1/4-in. lines from the top of each rear column and one line from the top of each front column. After the track platform was erected, the derrick tower was moved back half way to the end of the power house and erected the 90-ft. girders, the track platform, and the power house. The two halves of each of these girders were assembled in a horizontal position on the ground and were there completely riveted together. The finished girder, weighing 16 tons, was hoisted by both booms connected to it with chain slings. The most difficult lifts were the eight-ton cantilever girders, which were hoisted with a very flat boom.

After the completion of the towers as high as the

European Practice on Waterways.

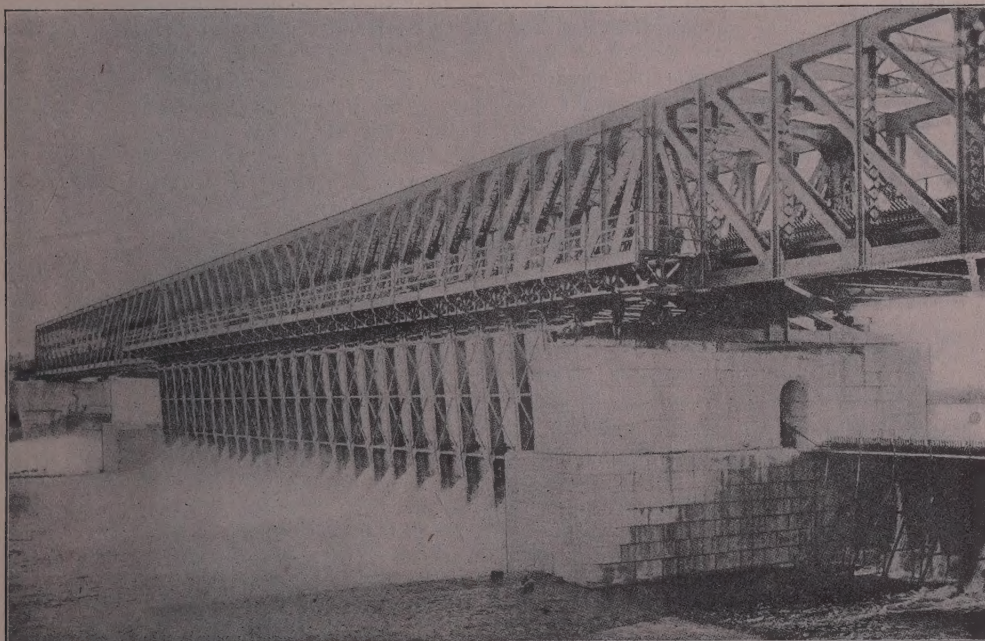
Report Submitted to the State Engineer of New York in April, 1906, by Mr. D. A. Watt, M. Am. Soc., C. E., Expert Lock Designer, Barge Canal Office.

The localities visited comprised points on the Lower and Upper Seine, the Yonne, the Marne, the Oise, the Saone, the Rhone at Lyons, the Po, the Danube and Danube Canal at Vienna, the Moldau, the Elbe, the Spree, the Main, the Ems, the Rhine and the Thames. The Dortmund-Ems, the Teltow, the Spree, the North Sea, the St. Denis and one or two minor canals were also visited, and inspection made at various points of quays and docks, winter harbors and river ports. The types of dams examined comprised bridges and curtains, bridges and gates, trestles and curtains, trestles and gates, needles, Chanoine wickets, Stoney gates (plain and revolving), drum weirs and cylindrical or rolling weirs. Some of these were of recent construction, while others dated back from twenty to forty years.

Recent and Projected Construction.—In each of these countries I found the question being agitated of a further extension or improvement of their waterway systems. The French will construct the new Canal du Nord, some sixty or seventy miles long, in the northern portion of the country, with the object of opening another coal field, and are considering other enlargements of their systems. Their most recent work has been the reconstruction of the locks and dams on the Oise, to afford better facilities for traffic. Italy and Austria are both agitating the expenditure of enormous sums for new canal and river improvements, and in the latter country the Elbe-Moldau canalization is proceeding steadily, and will in a few years connect Bohemia with the waterways of Germany. Several small canals, such as the Teltow, are under way in Germany, and a new east and west trunk line, which will ultimately connect Berlin with the Rhine, has been approved. They are also continuing the improvement of certain rivers by dikes. Holland is enlarging the North Sea Canal and deepening it from 26 ft. to 32 1/2 ft., and has some inland canal improvements under way, while in England some of the Thames locks near London have been rebuilt for larger traffic, and the question is being discussed of enlarging certain old canals and constructing new ones.

Depth of Waterways.—The prevailing depths for traffic run from 4 to about 8 ft., the former being found on certain diked rivers during low water, and the latter on some of the recent canals, such as the Dortmund-Ems, where the boats draw up to 6 1/2 ft. The new Canal du Nord will have 7 1/2 ft. on miter sills and boats drawing 5 1/2 ft., as they have to pass through shallower canals. On account of the great extent of the older canals with which all new ones connect, there seems no advantage to be gained by making the latter of great depth, unless for some special local traffic. It is probable, therefore, that 6 to 8 ft. will be the maximum depth for new improvements for many years to come.

Types of Dams.—I did not hear of any fixed dams having been constructed recently; for navigation, movable dams appear to have superseded them. Of the various types introduced in Europe since 1834—needles, Chanoine and other wickets, drums, Boulé gates, and Caméré curtains—two appear now to be recognized as the best, and practically all recent or projected dams have been or will be constructed of one or the other. These two are the needle and the gate dam, as they have been found to combine in the greatest degree cheapness in first cost and simplicity in operation. The chief advantage of the Chanoine wicket, speed and freedom in lowering, which has led to its adoption on the larger American rivers, does not appear to be required on Euro-



Bridge Dam with Boule Gates on Moldau River in Bohemia.

horizontal pane of plate glass 1 in. thick set in the floor, enabling him to see downward to the deck of the coal barge.

The tower was designed by the engineering department of the New York Edison Co. The steel work was fabricated and erected by Post & McCord. The steel work was built at the Ambridge plant of the American Bridge Co., and the hoisting and handling apparatus was installed by the Mead-Morrison Mfg. Co. The 500 tons of structural steelwork was erected by Post & McCord, with a force of 30 men in about six weeks.

Erection.—Most of the steel was handled by two 12x12-in. 55-ft. 10-ton derrick booms mounted on a tower 24 ft. square and 168 ft. high. This tower was built of four 12x12-in. vertical posts braced together with 6x8-in. horizontal timbers 26 ft. apart vertically on each of the four sides. The lower ends of the columns were seated on 12x12-in. sills 30 ft. long, and the panels between the horizontal struts were X-braced with diagonal rods 1 in. in diameter, pin-connected to the steel plates which form the splices for the column sections and receive the connections for the horizontal struts.

The top of the tower was braced by horizontal diagonal rods in the planes of the 10x10-in. upper

tower derricks would reach, the upper portions of the steel work were erected by two 8x8-in. gin poles 40 ft. long. The derrick tower was erected in five days by derricks on the power house.

A POSSIBLE ECONOMY IN POWER PLANTS containing air compressors lies in the utilization of the heat wasted in cooling jackets and intercoolers. It is customary to allow the cooling jacket and intercooler circulation to run to waste, whereas the cold water supply to the boiler feed pumps may be utilized for this cooling and the heat wasted in the jackets and intercooler thereby reclaimed. At the Kingsland shops power plant of the Lackawanna R. R., described on Jan. 5, the cooling jacket and intercooler circulation from the air compressors is discharged directly into the open feed-water heater, this circulation being ordinarily allowed to flow at a constant rate, while whatever is needed in addition for the boiler feed service, is supplied from the water service mains through the regular float control valve. As the jacket and intercooler circulation enters the open heater at temperatures from 100° to 150° Fahr., according to the rate at which the compressors are operated, it is evident that a material saving is made.

pean rivers, as rises on the latter are comparatively slow and drift is not so dangerous, and accordingly no dam of this type has been built during the last twenty-five years. Engineers who had had experience with bridge and gate dams and with other types informed me that for certainty and ease of operation the bridge type was superior to all, its only objection being its greater cost. At Martot, on the lower Seine, the existing needle dam is to be replaced by a bridge and gate dam, because of the superior advantages of the latter, and at Mirowicz on the Moldau, where is to be found a new dam of this class, the advantages have been equally appreciated. There are here three openings, a trestle and needle weir at each side and a pass closed by gates and operated from the bridge in the center. The weirs were to be used in regulating, and the pass was to be opened only in floods. However, it was found so much more convenient to regulate by the pass that the process has been reversed; all regulation is done through it, and the needles are not touched except in floods.

The dams yet to be built on this improvement will be of the needle type throughout, except on the upper Elbe where, on account of water power, it is desired to keep up the dams all winter. The design for these has not yet been determined.

The only new type of dam which has gained a foothold is the cylindrical or rolling dam, described in the Proceedings of the International Engineering Congress at St. Louis, 1904. I visited one at Berlin as well as those on the Main at Schweinfurt, now three years old. It is a simple type and has given excellent satisfaction, and can be kept in use all winter. Several others have since been built and still others are in the course of construction.

Modification in Dams.—But little modification was found in the design of needle and gate dams as compared with those built 20 years ago. The trestles are still spaced about 4 ft. apart, and except where bridges are used, the parts are still kept small enough to be manoeuvred by hand or by a light winch. The needles are now all of the "hook" class in the new dams, and the escape-method of manoeuvring has been abandoned, as its rapidity of operation was found unnecessary and it caused much bruising of the needles. In the hook type the head of each needle is provided with an iron hook which passes over the escape bar (Fig. 1). In releasing, the needle is pulled up a few inches until its foot clears the sill, and it then swings free in the water, the hook preventing its being carried away, but permitting it to be removed at leisure. Plain round support-bars have, therefore, been substituted for the old rectangular swinging bars.

In Boulé gate dams the only change of importance has been to provide ball bearing rollers on the gates, which allows a much easier operation. Experience has shown, however, that these rollers must be washed out every month or so, or sand and mud will clog them, and they must be kept free from oil or grease which would catch grit and choke their movement.

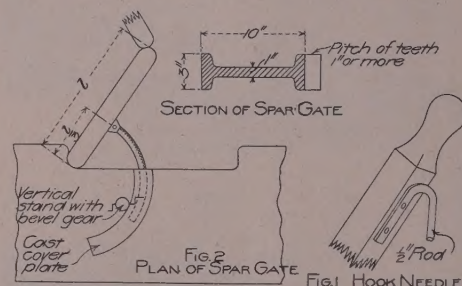
On the Mirowicz dam the gates (which are of iron) have been provided with Stoney rollers, and made about 6 ft. wide by about 17½ ft. high. They are operated by electric winches. On the new Oise dams, iron gates are used on the passes about 13 ft. wide and 1½ ft. high, the normal head being about 5 ft.

On the lower Ems are several needle dams recently completed, and worthy of note from the fact that each one has only a single opening, no center pier being used, the sill being placed all across at the same level.

Design of Locks.—No special difference was noticed between European and American designs

for locks, except as regards the side walls. These were found plumb in some cases and battered in others; sometimes with vertical wooden or iron fenders from 20 to 40 ft. apart to prevent boats from scarring the masonry, and sometimes with none; in some cases, as in the new locks of the lower Ems (placed in derivations), the sides were of ordinary rip-rap laid on the graded earth, the ends of the locks alone being of masonry with a line of piles between to keep boats off the grade. Elsewhere, as on the Main, a similar design was seen, but with no guide piles and with the graded earth protected by masonry laid in cement. These sloped side walls, however, were not as common as vertical ones. The principal difference noted was in locks of wide chambers, say 45 ft. or over, and with these the entrances were made narrow, from 30 to 40 ft. across, and the full width given in the chamber only. This is done with the object of using shorter gates, thus supposedly reducing liability to damage and reducing the cost. These advantages are gained, however, at an expense of time in locking, since the boats have to be moved sideways in the chamber, and some of the lock-tenders do not favor the method. The largest chamber of this type was at the Horin lock on the Moldau, its width being 72 ft., and its available length 465 ft. The entrance width appeared to be 35 or 40 ft.

Materials of Construction.—Concrete appears to be rarely used except for foundations, and a new lock on the Thames and one in the Netherlands were the only cases I met where all the walls were of this material. Elsewhere the walls were



Details of European Waterway Structures.

of one-man rubble masonry, of brick with cut stone coping and trimmings, or of cut stone of small dimensions. No locks were seen where the stones were as large as those used in this country as they seem to use machinery to a very limited extent, and employ therefore dimensions which can be handled by one or two men. This preference for hand labor on large works such as locks and dams, bridges, excavations, etc., was a noticeable feature in all the countries visited. The brick walls, some of which were 20 years old, were in excellent condition, the faces in many instances being built on a batter or provided with vertical fenders.

Lock Gates, Valves, Spars, Etc.—The majority of the lock gates were of metal, or of metal frames, with wooden sheathing. Few wooden gates were seen except in the older locks. They were all of the mitring type except on some canals where single leaves were used, and at the Horin high-lift lock where they closed against a bridge in a straight line. Lift gates closing the chamber like a vertical sluice gate, were only met with at the twin locks of the Teltow Canal near Berlin, the largest gate being about 30 ft. long and 26 ft. high. The engineers seemed well pleased with them, but they had not at that time been in use.

The gate spars in the majority of cases were of cast iron, forming a segment of a circle, of I-beam section lying on its side, with the rack as part of the casting (Fig. 2). On the large Seine locks this I was about 10 in. wide, with web and flanges 1 in. thick, and flanges 3 in.

wide. Straight spars were also found, and segmental spars stiffened with arms. Usually they were attached at about one-third of the length measured from the hollow quoin, and not from the toe as is usual in America. The arrangement worked very satisfactorily, and allowed the use of a much shorter spar than with us. Their practice in this respect could in many cases be copied with advantage. In all cases the spars were placed below the coping in a recess, covered by iron plates, and were worked by cranks on a horizontal shaft, fixed on a stand and turning bevel-gears which connected to the spar. Only one case was seen, at Creil on the Oise, where the spar was worked by a direct-connected pinion, turned by a man walking round.

The type of culvert valve most used in France was the drum valve, lifting inside a water-tight cover. On the Moldau, gate valves were used at several locks, moving vertically on fixed rollers and counterweighted. These had given excellent satisfaction. They had also used for the lock of 9-meters lift a sector valve like a Taintor gate, on a horizontal axis, and were well pleased with it. Valves turning on a vertical axis were also found. Nearly all locks had valves in the gates in addition to culvert valves, but they were rarely used, and seemed to be considered chiefly as a precaution in case of accident to the latter.

The most interesting design in this class was that of the siphon culverts, seen at the Teltow locks. The filling and emptying culverts are siphon-shaped, and the water is made to flow or to stop by exhausting or admitting the air in the bend. There is no machinery of any kind except air valves, as the vacuum is derived automatically from the head of water and produced in a vacuum chamber. The opening of a hand valve is followed in 20 or 30 seconds by the flowing of the water, and this can be stopped in the same time. There is also no loss of water from leakage. The system has been in use for some years in the Elbe-Trave Canal, and is being put into a new lock near Berlin. I asked several engineers about the system and they all spoke of it favorably, the only objection heard being that the flow could not be stopped in case of accident to boats as quickly as with culvert valves. The difference, however, would be only a few seconds and in point of fact it takes almost as long in one case as in the other.

Lock Floors.—On the latest large lock on the Moldau, of 72 ft. width of chamber with a gravel foundation, the floor was composed of loose rip-rap, placed on the gravel, except where stronger protection was needed, as at the culvert mouths. Owing to the wide span, a solid floor sufficient to resist upthrust would have been too expensive, and I was informed that the method adopted, a permeable floor, had so far given no trouble in other locks. They had had one solid floor break up under a head of about 14 ft., the lock being 37 ft. wide and the floor 2½ ft. thick, composed of concrete laid directly on the gravel, and without piles. This failure was attributed to the water getting into a ditch dug during construction under the floor site, and which it was supposed had not been properly filled up. In making repairs, holes were drilled through the floor about 15 ft. apart, to relieve any pressure. The Chief of Construction expressed the opinion that the only way to secure freedom from trouble in a solid lock floor was to make it strong enough to resist the upward pressure. His experience had not been favorable to relying on a system of underdrains, as he considered them too uncertain in their action. The big sea lock at Ymuiden, 82 ft. wide and built on sand also relies on holes in the floor, filled with gravel, to resist upthrust.

Guide Cribs or Walls.—Guide cribs were no-

ticeable by their absence, and even fender cribs to protect the ends of the lock walls were rarely seen. The absence of the latter I think was due largely to the rounded corners on the boats; when they glanced against the corner of a wall, there was little tendency to break it, as is the case with the square-cornered barges of American rivers. The absence of guide cribs appeared to be due to the fact that the locks are usually placed in derivations where there is of course no current, and that the rivers are much less subject to the rapid currents and sudden floods prevailing on most of the rivers here. For this reason in the few cases where the locks are built in the river, the currents rarely embarrass boats.

Operation of Locks.—Few locks were operated by power, and only one case was seen, at the Muhlen Dam, in Berlin, where hydraulic power was used for all purposes. At this place the power was obtained from an accumulating tank, filled by pumps operated by an automatic turbine. The lock gates and culvert valves were moved by direct-acting pistons, and the whole seemed to work very nicely. At Poses electricity was used, derived from a turbine and dynamo; and at Munster and Horin a similar arrangement was found. At Mirowicz a naphtha engine was used instead of a turbine to produce electricity, and at Henrichenburg on the Dortmund-Ems Canal lift, and Ymuiden on the Amsterdam ship canal, steam was employed. The motors for the gates and culverts were usually placed on the walls, and operated by a man on the spot, and not from a central house. The latter was sometimes provided, but did not seem to be used.

The arrangement most favored for the power was to use storage batteries sufficient for a run of 24 to 72 hours, according to needs. The dynamo under this method was then run only a few hours each day, and in cases of accident to it there was always a reserve of power. Although the batteries are costly, engineers who had had experience with their use told me that they had found it preferable to have them. They were installed at Munster after a few years' trial with the dynamo alone, and were in use also at Essen, Ymuiden and elsewhere.

High Lift Locks and Mechanical Lifts.—The only mechanical lift visited was the 46-ft. one at Henrichenburg on the Dortmund-Ems Canal. This lift has been in operation for six years during which time it has only been stopped three days from accidents. It works well, but it is a complicated piece of machinery and the breakage of one part might lead to the breakage of many others. It takes, with the power house, a crew of 17 men, working in day-time only, and its cost with grounds, etc., was \$660,000. The estimate for locks instead of the lift had been \$500,000. The engineers informed me that while the lift was well designed, and had proved quite satisfactory, they always had fear of accidents, and for that reason in the expected enlargement of traffic facilities at Henrichenburg they were going to build two locks of 21 ft. lift each, and would not build another mechanical lift. The adoption of the present one was partly due to the attraction of building a unique work and partly to its economy of water. They considered it best to use two locks for the new work instead of one, as the foundation was not of rock, and they appeared dubious as to the working of a lock with a 42-ft. lift.

The locks with the highest lifts were those at the head of the St. Denis Canal in Paris (32.2 ft. with a maximum of 36 ft.), built on rock in 1890 and 1891, and the one at Horin on the Moldau (30 ft.) built on gravel in 1902 and 1903. Both of these have been operated without any difficulty having been experienced from their great lifts.

Stoppage of Leakage in Movable Dams.—The

old methods of stopping leakage in movable dams by means of canvas, weeds, etc., have been replaced by using ashes or fine gravel dropped from a boat along the up-stream face. The currents leaking through draw the particles into the crevices, and make them water-tight. One tender of a needle dam told me that by this method the down-stream face of the needles would become perfectly dry. Weeds, etc., are only used to stop unusual leaks. The chief cause of tightness in all types of dam appeared to be due to the water weeds which grew on them when left in place any length of time, as well as to blades of grass, leaves and similar floating debris being drawn into the cracks.

Rusting of Ironwork.—There was very little rusting noticed in parts exposed to water. The ironwork of the dams on the Lower Seine, now 20 years old, were hardly affected, and on the Saone I visited a dam 40 years old, where the trestles and other ironwork looked good for another 40 years. This was no doubt due to their being made of iron, and not of steel, but in Germany where steel is used, the rusting was much less than found on dams in the Ohio Valley. The difference may perhaps be due to the supposed presence, in the latter case, of sulphur in the water derived from the coal regions through which the streams flow.

At the sea-lock at Ymuiden the lock-gates are removed one at a time every six years and cleaned and tarred. To do this a complete duplicate set of gates is provided.

Saturation from Pools.—On the Yonne and upper Seine I saw several locks where the pools for half a mile or more came within 2 ft. of the top of the bank. These rivers have a very flat slope. As the land sloped back from the bank, portions of the fields behind were on a level with or below the level of the pool. There was no trace of any trouble from saturation, however, and in some cases good crops were growing on such places. Probably any seepage sank down and ultimately escaped below the dam.

The engineers of the Dortmund-Ems Canal told me that in canalizing the Ems they had found it best to keep the pools not less than 3 ft. below the level of the land, except in sandy soils, where it could be kept about 2 ft. below. If these distances were exceeded, there was a tendency to saturation.

In Holland I saw large tracts of land permanently below water level. They were intersected with ditches from about 30 to 100 ft. apart, connecting with a main drain, on some point of which would be seen a windmill pump to raise the drainage water to a higher drain or to a canal. The surface of the fields was barely more than a foot above the water in the ditches, and it was all used as pasture. Where the level was a little higher, as 2 ft., vegetable gardens were seen, and the ditches where large enough were used to convey materials and produce by means of boats.

Methods of Towing.—The towing is chiefly done by propeller tugs, with occasional side-wheelers. The latter type is used largely on the middle and upper Rhine, and they are very powerful boats. On the older canals horse towing is still in vogue. The largest tow I saw consisted of seven barges, and all towing is done with the boats in a long line behind. On the open rivers there is plenty of room for this method, since their width appears to be a good deal more than that of rivers of corresponding length in America, while on the canalized rivers floods are infrequent and less violent than in this country. The method accordingly works very well, except that it causes a good deal of delay at locks. By the American method, where the fleet is all lashed together, the steamboat pushes its tow directly in or out of the lock; by the

French way, each boat has to be floated in slowly (as it is beyond the control of the tug) and tied up, and in leaving the lock, the tug has to proceed very cautiously until all the boats are under way, for fear of breaking the tow-lines. These manoeuvres with a large tow take much time. One lockage of 7 or 8 pieces I timed at over an hour, of which probably twenty minutes were taken in working the gates and filling the chamber.

Chain towing is also used in places, the chain lying along the bottom of the river and being passed over sheaves on the boat. I was told in Germany that the method was not as economical as had been expected, as the boat did not fully benefit by the current when going downstream, and that accordingly the system was not looked on with favor, except for assisting a boat to surmount specially swift places.

Experiments With Models for Dike Work.—In Berlin the Prussian Government established in 1902 an experiment station where proposed improvements by dikes can be investigated by means of models. To conduct such an investigation, a wooden trough is first made, and in this the unimproved river bed is carefully moulded in materials which will closely represent natural conditions. The water is supplied from a tank, the velocity of flow over the model being regulated by a formula of Prof. Engels, of Dresden, as is also the size of the sand or gravel used to represent the natural bed. At the time of my visit an experiment was in progress for increasing the depth in a bend in the Wartha by using spur dikes, the scale of the model being 1 to 100 for all vertical and horizontal measurements, and the scale of the material of the bed being 1 to 8. The results had showed that the low water depth could be increased from the existing 3 or 3½ ft. to about 4½ or 5 ft. Such an experiment is usually conducted for several weeks or months, the water being regulated to correspond to the natural variations of low and high water flow, and the little dikes being moved or adjusted to see which arrangement will produce the best results.

A similar experiment station was established several years previously by Prof. Engels, and as far as the lapse of time has been able to show, the results obtained in actual construction have followed closely the indications of the models.

Revolving Stoney Gates.—At Richmond I saw a novel arrangement of Stoney gates at the dam built across the Thames there about 1893. The dam is of the bridge type with three openings, each of which is closed by a single gate about 66 ft. long and 11 ft. high, sustaining a maximum head of 8 ft. When a gate is raised, and after it has cleared the water, a projecting crank-like arm attached at each end near the center of gravity, and traveling in a gradually curved slot in the side walls, begins to turn it from its vertical position, so that when the gate is fully raised it lies horizontal. This arrangement not only saves head room, but avoids the unsightly appearance of a gate which always remains vertical when up. The gates are counterweighted and each one can be raised by two men in about fifteen minutes. They have been satisfactorily operated twice daily (as they are tidal gates) since 1893, and the type would appear to be very suitable for guard gates.

Shape of Boats.—Barges of the model of the Erie Canal boat, with blunt ends and little regard for the resistance of the water while moving, were rarely seen except in France. In that country, where canals have existed for centuries, most of the canal boats have these blunt ends, probably for the same reasons which have perpetuated them on the American canals, and they are still being built. On all the rivers, however, where there was plenty of room, such as the

lower Seine, the Rhone, the Po, the Danube, the Elbe, the Rhine, etc., I found that the barges were all built with model or with spoon ends, so as to reduce the towing resistance to a minimum, except when they had to traverse the older and smaller canals, and then they sometimes had blunt ends. On the Dortmund-Ems Canal, however, where the locks admit barges carrying about 850 tons net, specially built model-end barges were in use, showing that the additional gain of cargo room which blunt ends permit was considered of less importance than the increase of towing power which they require. On the Rhine and other German rivers I saw many steel barges of capacities from 250 to 2,000 tons, all with model ends, and some with lines as carefully molded as those of an express steamship.

It was evident that the old blunt ends had been entirely discarded except for small craft, and on these they were rarely found except in France. With small boats of this type the gain in cargo space may be worth considering, but with large boats its proportion to the whole becomes unimportant, and, judging by the practice evolved in Europe, model ends must be used if towing expenses are to be kept down. This is entirely in keeping with the experiments of DeMas and others, and as the cost of towing is so large a proportion of the cost of transport, the reduction of the moving resistance becomes a matter of high importance.

Electric Traction.—This type of traction does not appear to have made much progress in Europe as yet, there being less than 100 miles of canal so equipped, although more extensive construction is contemplated in the near future. This failure to have made headway appears to be largely due to the fact that where the motive power is derived from coal, there is much doubt as to whether electricity is any cheaper than using steam tugs. As compared with electric locomotives the tugs are, of course, much more wasteful of power, but they avoid the heavy expenses for the construction and upkeep of tracks and wiring needed for locomotives. While electricity is naturally advocated by the electric companies others well qualified to judge told me they had great doubts as to its economy where the power was derived by artificial means. In cases where the power can be obtained from a natural force of water, however, these objections disappear.

Three systems of electric traction have been applied, as follows: (1) By locomotives running directly on the surface of an ordinary towpath. (2) By locomotives running on a track placed on the towpath. (3) By electric tow-boats.

The first system was applied on a canal in the north of France, but after fair trials it has been given up, as the locomotives cut up the towpath badly, necessitating constant repairs to it. A rail track is to be substituted.

The second system appears to be the favored one where the power is costly. The Siemens-Schukert Co., of Berlin, have spent some \$40,000 in experimenting during two years on the Teltow Canal, and have evolved a locomotive which runs on a track along the towpath, taking its power from overhead wires in the usual way. It was shown to me in operation. It is provided with drums for winding in or out the tow-line and with an arm for raising the line when passing boats tied to the bank. For passing the opposite traffic it was found advisable to use separate tracks, one on each bank, thus permitting east and west-bound boats to have entire independence. It was feared that if both tracks were on the same bank and the tow-line of one boat was dropped as is done on the Erie Canal, the rate of speed might cause entanglement with the bottom of the canal, when a collision would result. Part of the canal runs through ponds or

small lakes, and in these the traffic will be transferred to naphtha tugs, as electric tugs with overhead wire were objected to on account of the unaesthetic appearance of the poles. The canal will be equipped therefore with a track on each bank, and with 20 electric locomotives deriving power from a central station, the economical speed being determined at three miles (5 km.) per hour.

The third system, that of electric tugs, was also tested in a series of experiments on this canal, the boat used being of 70 h.-p. For the final experiments it was provided with three propellers, to reduce the stern wave action, as the canal banks are not protected. In this respect it is very successful, as I could see when comparing it side by side with an ordinary steam tug. It is also provided with storage batteries containing power enough for a five hours' run, in case of failure of the current, or for use when manoeuvring.

In the early experiments the boat was tried with fixed trolley arms, as used on street cars, but this method necessitated it moving always directly under the wires, and allowed none of the freedom of action indispensable to a boat of this class. It was therefore abandoned, and the Lombard-Gérin system adopted of taking the power through a cable, one end of which is attached to the boat, and the other to a motor trolley which travels directly on overhead wires. This trolley is regulated by a switch on the boat, and can be controlled to move backwards or forwards and at the speed desired. The cable forms a flexible power transmitter, and allows the boat to move to either side for a distance of 16 ft. or more, and to turn or make other manoeuvres with great ease. I saw the system in operation on a stage line near Paris, and it appeared to be the only practicable way of operating an electric tug, unless storage batteries were used.

Locomotive versus Tug.—The economic installation of electric traction appears to depend primarily on the cost of power. With locomotives there is the cost of the tracks, but there is a small waste of power, while with the tugs there is no cost of track, but much waste of power. In the Teltow experiments it was found that the efficiency of the locomotive was 65 per cent. as against 25 per cent. for the tug. This agrees closely with M. Lombard-Gérin's statement to me that a tug used about two and a half times the power of a locomotive. The cost of the 24-h.-p. locomotive was about \$3,500, and of the 70-h.-p. tug about \$8,000. Each could tow 1,000 tons at nearly three miles (5 km.) per hour, the tractive force on the line being then equal to 2,200 lb. (1,000 kg.). The equivalent, I was told, as determined from these experiments was 1 h.-p. per 33 tons at three miles (5 km.) per hour for the locomotive, or 1 h.-p. per 14½ tons for the tug.

Where no towpaths are available, and power is cheaply derived, the Siemens-Schukert Co. and Mr. Kœchlin, of the Compagnie Générale d'Electricité, of Paris, both expressed the opinion that the trolley tug would appear well adapted to the case. For crossing open water, it would have to rely on storage batteries placed in the hull, or else to take in tow for the passage a special craft carrying a relay of such batteries.

Economical Aspects.—The present general prosperity, accompanied by the development of old and new industries and a corresponding growth of traffic, has led to the extension of existing waterways and proposals to build new ones, as described in the first part of this report. These waterways usually carry a heavy traffic, although on some of the older canals and some of the rivers, as on the Rhone, where much commerce might be looked for, there is actually very little.

The traffic is, of course, dependent on the same conditions as those which affect railways; for much freight to be carried, a rich country must be traversed or connected with, the terminals must be at a seaport or an important city, and there must be intercourse with connecting lines. The country along the Rhone is chiefly agricultural and the traffic therefore light, as the products are shipped by rail, and a waterway appears to be successful only where there are bulk goods to handle, as coal, lumber, etc. The Rhine, on the other hand, affords an example of the opposite class; its tributary country is rich in coal and manufactures; it has many large cities upon it; it has a seaport connection at Rotterdam, and communication at various points with the greater portion of the canal and river systems of Europe.

The evolution of rail and waterways appears to have passed through the same processes in Europe as are in progress in this country. The rivers and canals were at one time the only means of cheap transportation; later the railways began to supplant them and then to divert their traffic purposely in order to destroy competition, and 25 or 30 years ago commerce had been so far driven from the waterways that they had almost lost their usefulness. The growing dangers from absence of competition in freight rates, however, began to be apparent, and between 1875 and 1885 a general reconstruction of the waterways took place; the old ones were deepened, new ones were built, and the attempt made to provide highways of transportation which would be deep and large enough to permit cheap rates. In a few cases, as with lines not well situated economically, the effects were not as beneficial as expected, but in general the results were a great success; commerce was stimulated, new industries sprang up, and while the railway traffic declined for a time, it eventually received much benefit from transporting the manufactured products of which the raw material came by water. Thus the commerce on the Rhine, which probably offers the most remarkable example of development, was about 3,600,000 tons in 1880, while by 1900, when the improvements were about complete, it had risen to 13,100,000 tons, and is still increasing. It was estimated that the saving in freight rates during the latter year alone on the business handled at the river ports on the German Rhine was more than ten million dollars.

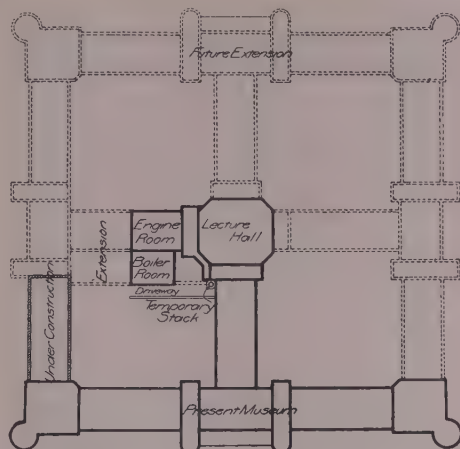
In planning new waterways at present, they are no longer built for miscellaneous transport as in the early days, since experience has shown that they can only be an economic success when there are bulk goods to be carried, and that the same principles must govern their location as are necessary for the success of a railway. The new lines are thus made to tap coal fields or important industrial centers, or to form communicating links between existing systems.

Tolls are levied on some of the waterways, the proceeds being devoted towards maintenance. It is not always that they are sufficient for this purpose, however, as the broader policy is followed of benefiting the district generally, and of levying tolls which will not discourage navigation and thus tend to counteract the advantages of cheap rates. By this policy new industries are established and old ones developed, and the widening field for taxation indirectly tends to more than supplement any deficiencies from the upkeep of the waterway. In some cases the gradual increase of traffic has eventually paid all the operating expenses. While examples are to be found in Europe of waterways which are of little benefit, either from their too small size, or from a faulty location from the standpoint of economics, the general results appear to show that these highways of transportation, when judiciously projected and built, are of far-reaching benefit to all classes of the community.

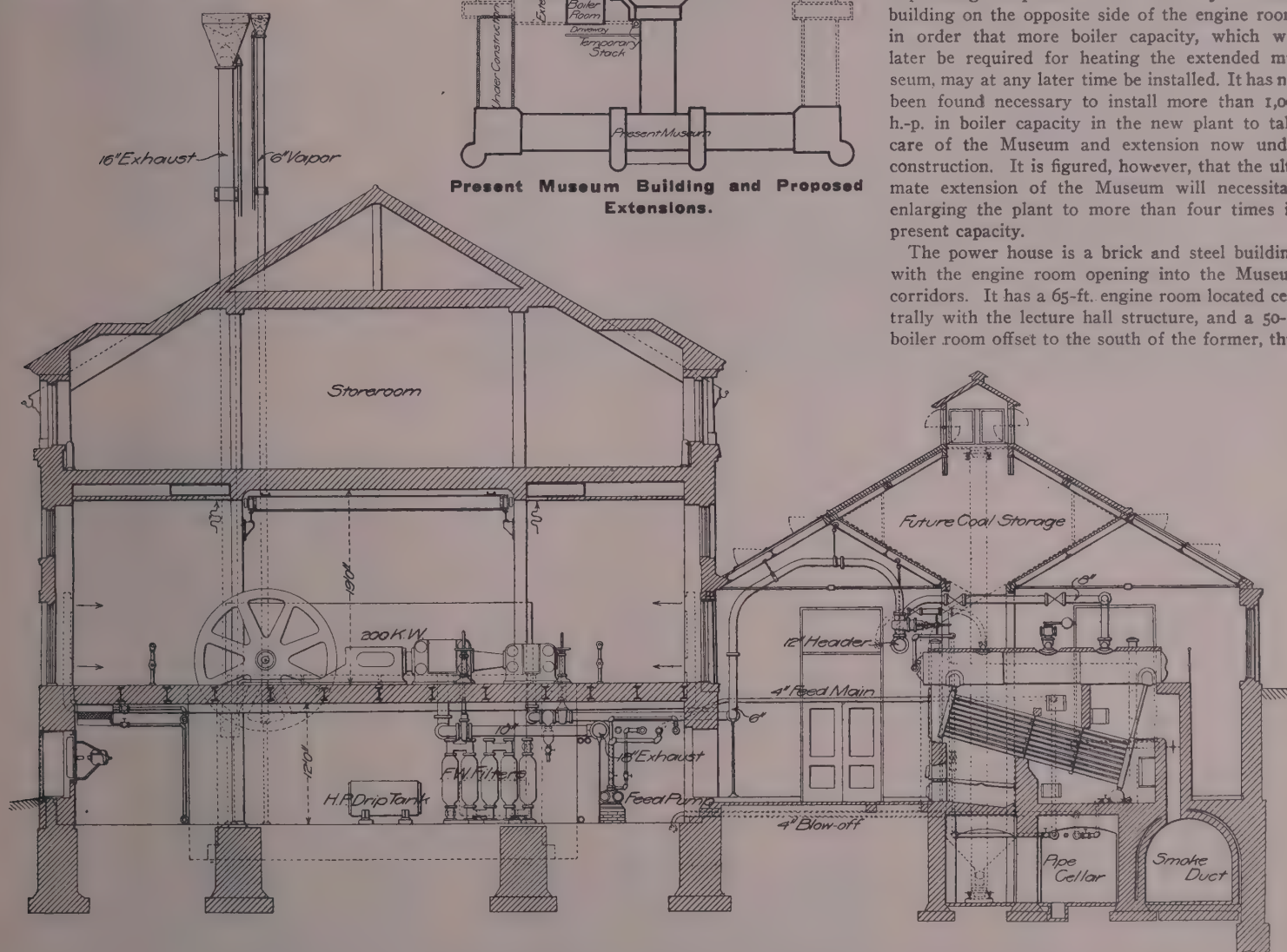
Power Plant of the American Museum of Natural History, New York.

As a part of the plan of extension of the American Museum of Natural History, in New York, a new power plant has recently been installed, which is of more than ordinary interest for the pleasing interior arrangement secured and the intention that it shall form one of the educational features of the Museum. With the present greatly increased importance of methods of power production and distribution, the desirability of incorporating materials and equipment of a historical nature, which have an important bearing on the use of power, has been recognized and the plant has been so located and designed that it will be susceptible of utilization for exhibition purposes. The plant forms a link in a scheme of expansion that has been planned from the orig-

ing have until recently been accomplished from a small power plant in the basement of the radial wing connecting the lecture hall with the main structure, which was of comparatively small size and of a temporary nature. It embraced about 700 h.-p. capacity in horizontal return tubular boilers and a number of small belted generating units, installed without provision for extension and lacking the conveniences of the modern power plant.



Present Museum Building and Proposed Extensions.



Cross Section of the New Power Plant of the Museum of Natural History, New York.

inal construction of the Museum, which will eventually result in a magnificent structure to cover the greater part of the 10-acre space between Eighth and Ninth Aves., and extending from 77th to 81st Sts., which has been reserved by the city for it. The original Museum building facing 77th St. and the lecture hall with connecting wing to the rear form the nucleus of the large structure which will be built in sections from time to time as the need for increased space arises. The architectural plan of the building involves a series of wings which will surround, in the form of a hollow square, the lecture hall as a center and will have a main entrance facing Central Park. An extension now under way comprises a 150-ft. addition to the westerly façade.

The heating and lighting of the original build-

With the construction of the extension to the Museum building, now under way, increased power facilities became necessary, and it was accordingly decided to provide them by a new installation which should replace the overloaded temporary plant and should be of such a design as to itself permit of sufficient expansion to provide for the ultimate extension of the Museum. As the buildings are to be heated by exhaust steam at very low pressure, it was desirable to locate the plant in the most nearly central position available, and, accordingly the space between the lecture hall and the projected westerly façade, which will form the rear portion of the Museum, was selected as the place nearest to the center of the site and most suitable for the power plant. At this point a distance of 300 ft. from the lecture hall

to the westerly façade is available, with extension longitudinally to any desired amount within the limits of the Museum building. Accordingly the power house has been built as a radial wing, connecting the lecture hall with the westerly façade, and harmonizing in its architecture with the remainder of the Museum, and has been so placed that extensions can be made without interference with any part of the main building.

While the ultimate development of the new plant is very extensive, only such portion of the power house and equipment has been provided as is needed for the service in the present buildings and the new addition which is now under construction. The equipment has been arranged with special reference to an increase of capacity by extension on the same plan and without interference with apparatus already in place. The power house building was laid out to permit duplicating the present boiler house by a similar building on the opposite side of the engine room, in order that more boiler capacity, which will later be required for heating the extended museum, may at any later time be installed. It has not been found necessary to install more than 1,000 h.-p. in boiler capacity in the new plant to take care of the Museum and extension now under construction. It is figured, however, that the ultimate extension of the Museum will necessitate enlarging the plant to more than four times its present capacity.

The power house is a brick and steel building, with the engine room opening into the Museum corridors. It has a 65-ft. engine room located centrally with the lecture hall structure, and a 50-ft. boiler room offset to the south of the former, thus

providing for the projected duplicate boiler house to be similarly offset on the northerly side. The building has at present been built to a length of but 75 ft. to the west of the lecture hall, the westerly end being closed off by a temporary blank wall which can be readily removed for future extensions. The engine room is a two-story and basement building, of fireproof construction, the upper floor of which is utilized as a storeroom for the Museum, while the basement is for the greater part devoted to the power plant auxiliaries. The engine-room floor is level with the main Museum floor, while that of the boiler house is depressed 11¾ ft. below or 2 ft. above that of the basement. The boiler house has a single story, with 21 ft. clear head room under the roof trusses, which are of special construction to provide for elevated

coal-storage bunkers, to be installed at a later period when warranted by increase in size of plant. Both boiler and engine rooms are amply lighted by side windows, the boiler house having in addition a considerable area of skylights. The offset location of the boiler house permits the use of an areaway at the lecture hall end for the use of coal and ash carts and for shipping facilities.

There are at present four Babcock & Wilcox water-tube boilers designed for operation at 200-lb. pressure. There are two 14-section and two 11-section boilers, each 9 tubes high, and having a total heating surface equivalent to about 1,000 h.-p. Each boiler has two 36-in. steam drums 23 ft. long. They are set in substantial brick settings with plain grates, and are arranged for three passes of the products of combustion, smoke connections being made from the rear of the settings by vertical brick flues to an underground smoke duct. The latter is a duct with arched roof, 8½ ft. in width and height and extends longitudinally under the floor at the rear of the settings, which will facilitate extension when the plant has to be enlarged. For the present, a temporary chimney has been provided, a 5-ft. steel stack alongside the lecture hall, to which connection is made from this underground flue by a brick-lined duct extended under the areaway at the easterly end of the boiler house. Each of the down-takes from the boiler settings is provided with dampers operated by Locke automatic damper regulators.

The boilers are hand fired, fine anthracite coal being used, which is at present dumped outside the boiler house and wheeled to the firing floor. The latter has a width of 20 ft. between the boiler fronts and the opposite wall. Ashes are similarly removed manually from the ash pits and thence hauled away by the ash-collecting carts of the street cleaning department. Arrangements have been made, however, whereby both coal and ashes will be mechanically handled whenever an increase in the size of the plant may warrant it. The boiler house is built with a monitor on the roof above the coal bunker space, and a longitudinal ash tunnel under the boiler furnaces extending centrally with the building, so that a longitudinal bucket conveyor may be installed to pass under the outlet hoppers of future ash pits, underneath the boilers and up above the coal-storage bunkers in the roof. The coal-storage bunkers, as designed, will be supported in part by the roof trusses and in part by two lines of columns over the front portions of the boilers, as illustrated in the cross-section. It is planned to extend downspouts from the bunker outlets forward and down to swiveling outlets, by which coal may be dumped in any position required for convenience in firing. The design of bunker is such that a maximum depth of storage of about 12 ft. is provided, the capacity of the bunker being about 5 tons of coal per lineal foot of bunker space.

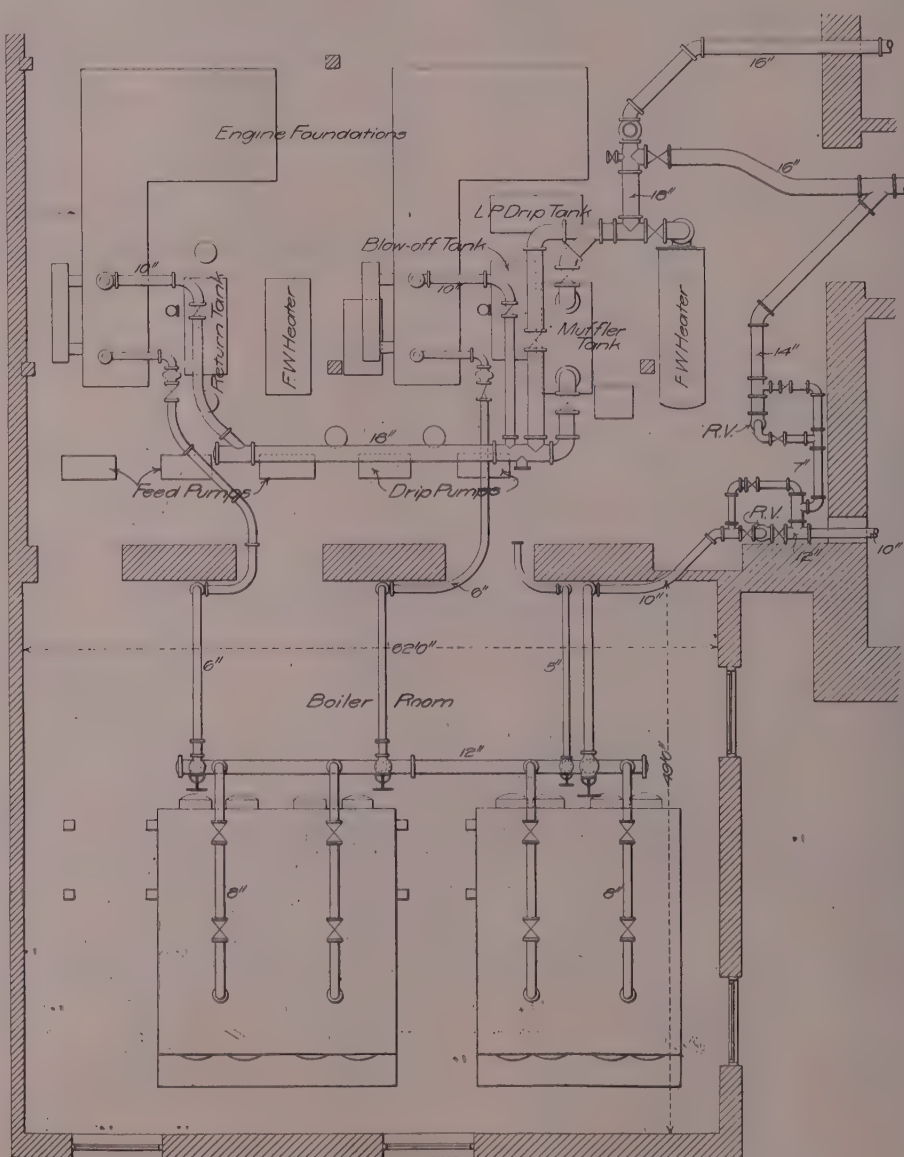
For the feeding of the boilers, condensation returned from the heating systems of the building and from the drip systems is utilized, make-up being taken from the city water mains. The heating system condensation is freed from lubricating oil, entrained from the engine cylinders, first by passing the exhaust steam through an 1,800-h.-p. Utility muffler tank and grease extractor, and subsequently by passing the returned condensation through a Ward combination filter. Both the muffler tank and the filter, as well as the feed and return pumps, are located in the engine-room basement. The latter are brass-fitted Worthington duplex pumps with 7½ x 5 x 6-in. cylinders and are piped to take suction from the return tank and deliver to the boilers through a 4-in. feed line. This line passes first through the filter and the feed-water heater, and thence to a distributing line in the 8 x 9-ft. pipe cellar between the ash tunnel and the smoke duct; from this, 2-in. branches are brought up to each boiler

front. The feed-water heater is a Berryman closed-tube heater of 1,800 h.-p. capacity and is connected inductively to the main exhaust line.

The blow-off system has a 4-in. blow-off header in the pipe cellar underneath the boiler settings, into branches from which two 2½-in. valved connections from the mud drum of each boiler, uniting into a single 3-in. connection, deliver. This header is extended at one end, across in a trench under the boiler-room floor to a blow-off tank in the engine room basement for partial cooling before entering the sewer, the tank being kept half filled for this purpose. The tank is a 4 x 9-ft. cylinder with a 3½-in. vapor outlet which connects into a vapor riser leading up to a roof exhaust head. The blow-off discharge and dirty drips are delivered from this tank direct by grav-

which are 6-in. lines with Cochrane separators to supply the generator engines, one a 5-in. branch to the pumps in the engine room basement and the fourth a 10-in. line which delivers steam to the former plant and heating system at a reduced pressure of about 60 lb. All changes in direction of the piping are made through long radius bends, and the header and branches are for the greater part flexibly suspended by supporting rods from the trusses. The piping is extra heavy and for the larger sizes is fitted with Van Stone joints.

The exhaust steam system has been laid out to provide amply for the contemplated extensions of the plant. There is an 18-in. main header carried through the engine room basement and connected at one end to the Utility muffler tank and grease extractor and extending beyond to connec-



Plan of the Museum Power Plant Showing Piping Systems.

ity to the sewer by an automatic valve operated by a float governor.

The steam piping system is simple and is designed to permit extension with a minimum of trouble and expense as the plant is enlarged. It centers in a 12-in. main header extending longitudinally through the boiler room over the boiler fronts, which is merely blanked off at the westerly end, thus permitting additional units to be connected without limit. Steam is fed from the boilers to the header by 8-in. branches, each fitted with two valves hung in an unusually convenient arrangement over the spaces between boiler settings, and so that the operating wheels are accessible from the tops of the settings. From the header four supply branches are taken off, two of

tions to the heating system, with an atmospheric relief connection through a back-pressure valve. The two exhaust connections from the generating units, the branch from the auxiliaries and all other connections are made through Y-fittings. The low-pressure delivery to the heating system is made through a 16-in. extension of this header, which is carried through the basement of the lecture hall and connecting wing; here connections are made to the heating and ventilating equipments of the buildings to utilize the exhaust supply from the new plant. A live-steam connection for make-up when the exhaust pressure is insufficient, is made from the 10-in. reduced pressure line to the former plant, delivery being made through a 7 x 14-in. reducing valve. The atmosphere re-

lif connection is a 16-in. riser with Kieley back-pressure valve and is carried up to an exhaust head above the roof line.

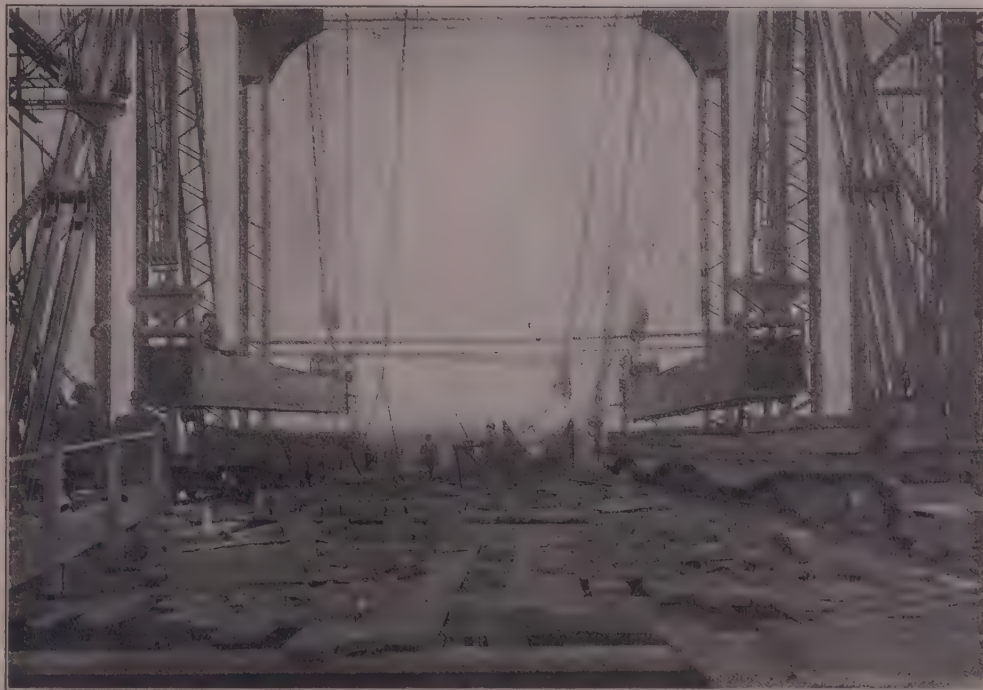
The electric generating equipment of the plant consists of two direct-connected units, each of which is of 200 kw. capacity and runs at 120 r.p.m., this size having been adopted as standard for the extended plant. The engines are the tandem compound type, with 15 x 26 x 36-in. cylinders made by the Hoover, Owens & Rentschler Co., and are fitted with reheating intermediate receivers. Both steam and exhaust connections are made in the basement, with the valves operated from floor stands on the main floor above. The generators are General Electric multipolar machines wound for 230 volts, direct-current, and have balance coils for operation in connection with auto-transformers on the three-wire system, for which the Museum is wired. The generators have two sets of series coils and two balance wires to the auto-transformers for the neutral lead. The circuits are controlled upon a temporary five-panel switchboard in one corner of the engine room, consisting of two generator panels, a totalizing panel and two feeder panels. Whitney instruments are used and I.T.E. circuit breakers. It is planned to relocate the switchboard in a more favorable position as the plant is enlarged.

As before stated, one of the important features of the plant is the interior finish; the engine room floor is laid in tile, the walls finished in white-enameled brick and the remainder in white, so that an unusually attractive result is secured. This room connects at the easterly side with the main Museum corridor to enable visitors to enter, and the machinery is surrounded by a railing. Ample space has been provided for exhibition purposes, as may later be desired. Large windows in the division wall afford an excellent view from the engine room into the boiler room below. The

Erection Attachments for Bottom Chords and Vertical Posts of the Quebec Bridge.

The south anchor arm of the Quebec Bridge is supported on two masonry piers about 60 ft. and about 30 ft. above extreme high water, or 22 ft. higher than extreme low water, as explained in several articles printed recently in this journal. It contains about 14,000,000 lb. of steel and has

all connections in the lateral, sway brace and floor systems are field riveted. All steel shipped from the shops at Phoenixville, Pa., is unloaded at the storage yard near the bridge site by electric traveling cranes of 68 ft. span and a vertical clearance of 30 ft. They are placed on transverse skids and piled to as great a height as can be cleared by the cranes. As opportunity affords, in advance of the time of erection, each member is taken from the general pile, turned end-ways if neces-



Pair of Vertical Post Sections Connected by Horizontal Tackles.



Hoisting Upper Section of Vertical Post.

boiler room and basement are similarly finished in white and are as attractive as the character of the equipment permits.

The new power plant installation of the Museum and the details of the heating equipment of the extension have been designed by Mr. Alfred R. Wolf, consulting engineer, New York. The contractors for this installation were Baker, Smith & Co., New York. The electrical equipment was designed by Mr. C. O. Mailloux, New York. Mr. Charles Volz, New York, architect for the Museum, designed the power house structure.

two pin-connected trusses 67 ft. apart and from 97 to 315 ft. in depth on centers. The truss members have lengths up to 300 ft., but were shipped and handled in the field in sections not more than about 70 ft. long, with maximum weights of about 100 tons. The principal truss members are connected with pins generally 12 in. in diameter and up to about 10 ft. in length. A peculiarity of the design is the provision of special jaw plates on the vertical posts with separate pins for the connections to the chords and to the diagonal eyebars. Secondary connections in the trusses and

sary, rolled into the proper position and any connections made or riveting done that can be advantageously accomplished on shore. The proper clamps, yokes or other devices are then attached to it and it is rigidly inspected to make certain that it is absolutely correct in every respect and lies in the proper relative position for delivery to the traveler, to be handled by its tackles and swung into exact position for assembling in the structure without requiring it to be turned or any additional alterations made on it. In this position it is placed on service skids from which it is quickly transferred to the service cars at the moment it is required for erection, so that in a few minutes it can be drawn by the locomotive to a position underneath the traveler and thence lifted by the tackles of the latter and swung into position in the minimum time.

Owing to the dimensions and great weight of the members, safety and rapidity of handling demand special appliances for connecting them to the hoisting tackles. Great care has been taken in designing these appliances, so that they will have abundant strength; can be easily adjusted and quickly handled; cannot become accidentally displaced or released; will permit the member to swing freely in the tackles and adjust itself to inclined positions or hold it rigidly in a given position; afford clearance with the other members connected to it; and can be easily removed after the member is assembled in the structure.

It is evident that ordinary slings, chains, hooks and clamps do not fill these requirements, and much time, skill and experience have been devoted to designing the large number of special appliances adapted to the different members. Nearly all of them are some form of yoke or clamp adapted to receive one or more tackles and to provide for positive engagement with the member lifted. Many of them are of massive construction, and all of them are so heavy that they must be handled by power tackles, thus in reality greatly reducing the manual labor of erection and relieving the

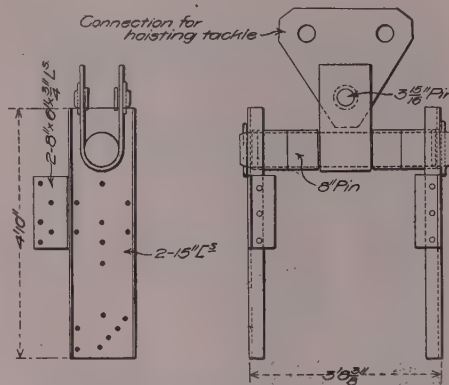
workmen from almost all lifting and setting, their work being that of adjusting and connecting the different appliances and locking them to the hoisting tackles, which is accomplished by an ordinary shackle and pin connection, triangular plates providing for the connection of two or three independent hoisting tables.

The bottom chord has a uniform rectangular cross-section, $4\frac{1}{2}$ ft. deep and $5\frac{1}{2}$ ft. wide, made with four built channels having their webs vertical and their flanges connected by tie plates and lattice angles. Their lengths vary from about 50 to 68 ft. and the cross-section from 301 to 735 sq. in. They are shipped to the site in single-panel lengths with a field-riveted splice about 8 ft. beyond the pin at the river end of each piece.

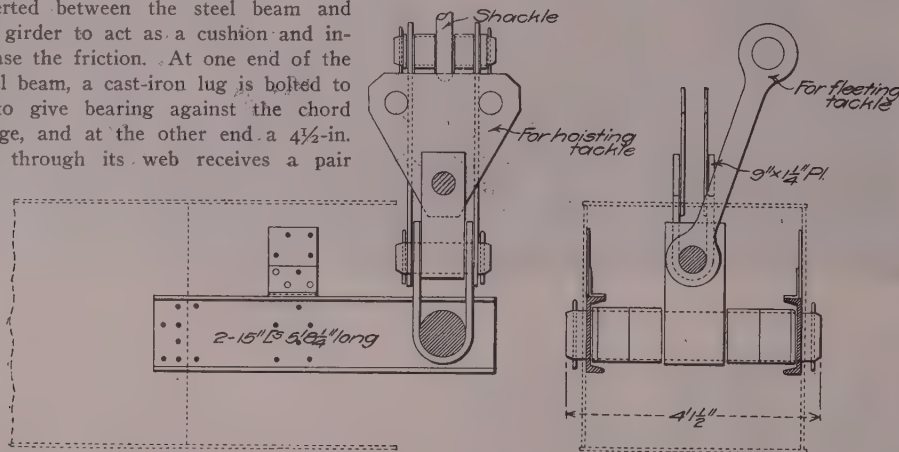
When it is necessary in the storage yard to revolve a chord about its axis, this is accomplished by means of a pair of duplicate appliances each of which consists of a clamp or yoke enclosing the chord and engaging a pivoted eye-bar connection to the hoisting tackles. The yoke is a transverse timber on one side of the chord and a steel beam composed of a pair of channels back to back on the opposite side. These are connected by screw rods which clamp them so tightly that the friction developed prevents slipping. A wooden filler is inserted between the steel beam and the girder to act as a cushion and increase the friction. At one end of the steel beam, a cast-iron lug is bolted to it to give bearing against the chord flange, and at the other end a $4\frac{1}{2}$ -in. pin through its web receives a pair

are provided with cast saddles acting as bushings to fit the large shackles on the blocks. This arrangement provides for the attachment of the main hoisting tackle to either pin, thus revolving the triangular plate about 30 deg. and affording an attachment for the transverse tackle on either side of the chord as required.

The chords near the main pier are steeply inclined to conform with the parabolic curve of the truss and the attachments for their river ends are



Attachment for Lower End of Post P1.



Attachments for Upper Ends of Post Sections P1, P2, P3 and P4.

of eye-bars a little longer than the depth of the chord, so that when revolved at right angles with the beam the hoisting tackle attached to its upper end will clear the chord. A yoke is placed near one end of the chord with its steel beam in a horizontal position underneath the chord, and at the opposite end a similar yoke is attached to the chord with the steel beam vertical. Tackles are then connected to the eye-bars of each yoke and, one of them being hoisted and the other slacked, turn the chord 90 deg. and deposit it on the other face without impact. These attachments are not used for lifting the chords, only for rolling them.

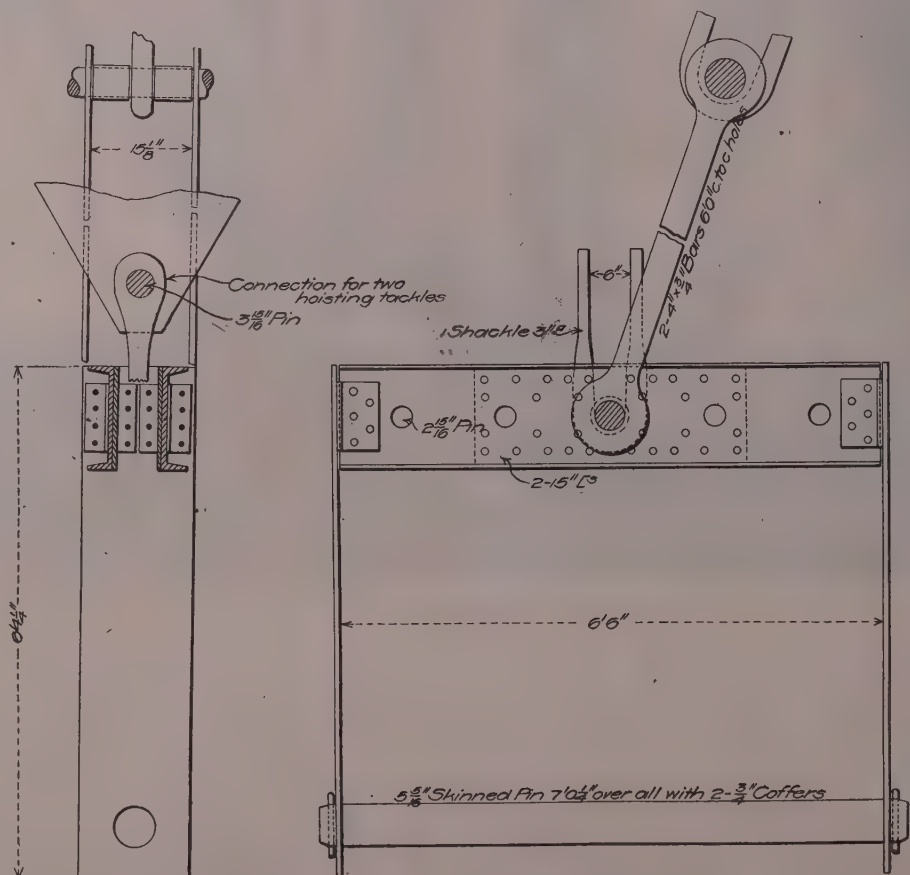
For unloading chords from the cars in the storage yard where they were handled only in a horizontal position, a simple device illustrated in The Engineering Record of Sept. 22, 1906, was used. It consisted merely of a pair of vertical riveted hooks suspended from the horizontal beam attached to the hoisting tackle and having their points locked together on the chord.

For lifting, erecting, and assembling the chords, they are handled by tackles at both ends connected to them by pairs of short channels secured to the chord webs parallel with them by $\frac{7}{8}$ -in. bolts through open holes in the chord inside webs left for that purpose, leaving the outside webs free for splicing. One end of the channels projects beyond the chord and has a 6-in. pin connected by a shackle to a pair of triangular plates with two other pins through them, one pin intended to receive the hoisting tackle and the other pin intended to receive a second hoisting tackle, a floating tackle or a transverse tackle to aid in the lateral adjustment of the chord. Both of these pins

made with special connections to the main pin passing through the short channels, which were bolted to the chords as already described. Here the pin engages a U-plate centered on it by filler rings and secured by a $4\frac{1}{2}$ -in. pin at right angles to the main pin. The $4\frac{1}{2}$ -in. pin carries in the center a shackle connected to a triangular plate like the one previously described, with two pins engaging links connected to hoisting tackles. These pins being of smaller diameter than the shackles, are provided with cast-iron saddles to fit the latter. Both the shackles are in the plane of the chord and distribute its weight, which may reach a maximum of 100 tons, between two 55-ton tackles. At each end of the transverse pin outside the U-plate connection, there is a single eye-bar in a plane perpendicular to that of the chord. These eye-bars, about 12 in. apart, are connected at their upper ends by a 6-in. pin which receives a shackle connecting it to a floating tackle which, in the second anchor arm, will be replaced by a horizontal manila tackle connecting it to the corresponding chord in the other truss, simultaneously erected.

The end floorbeam is a double plate girder weighing about 36 tons. It was handled by two pairs of hooks 5 ft. apart on centers which engaged the top flange. One hook of each pair was made of a 6x2-in. forged plate fitted between the two 6x1-in. plates which were riveted together with fillers to form the opposite hook. They were pivoted on a $2\frac{11}{16}$ -in. pin which engaged a $6\times\frac{3}{4}\times\frac{1}{2}$ -in. U-plate suspended from the transverse pins in a lifting beam direct-connected to the hoisting tackle by a swivel clevis which enabled the beam to be revolved 90 deg. from the car to its position. The solid-web intermediate floorbeams, 67 ft. long and 10 ft. deep, weigh about 32 tons each and were lifted in the same manner.

The intermediate vertical posts were each shipped in two or more sections field-riveted together to make a complete member. They were delivered to the traveler in a horizontal position parallel to the bridge axis and lifted from the service cars by a pair of tackles at each end. The lifting device at the lower end had a pair of chan-



Attachment for Upper Ends of Main Posts.

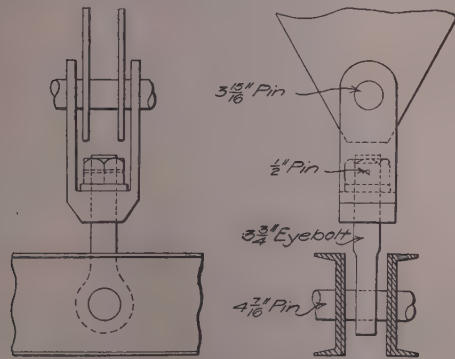
nels bolted to the jaw plates for the sub-diagonal. The channels projected beyond the edge of the plate where they were connected by an 8-in. pin which, at the middle point, received a 12x3/4-in. U-plate spaced to the required position by filler rings on each side. The U-plate was bored for a 4-in. pin transverse to the other pin which received a triangular plate with connections for two hoisting tackles.

This arrangement provided for the equalization of stresses in the two tackles and permitted the post to revolve freely above the large pin, while the two tackles at the upper end were operated to throw the post into a vertical position, in which it was suspended by them clear of the lower tackles, which were offset about 3 ft. from the center of the post. This connection was proportioned to carry about two-thirds of the total weight of the lower post section while it was being swung to position, after which the tackle at the upper end carried the entire weight. Similar attachments were used for the other intermediate posts, which weigh from 40 to 76 tons each and required separate channels of different dimensions and punching for each member.

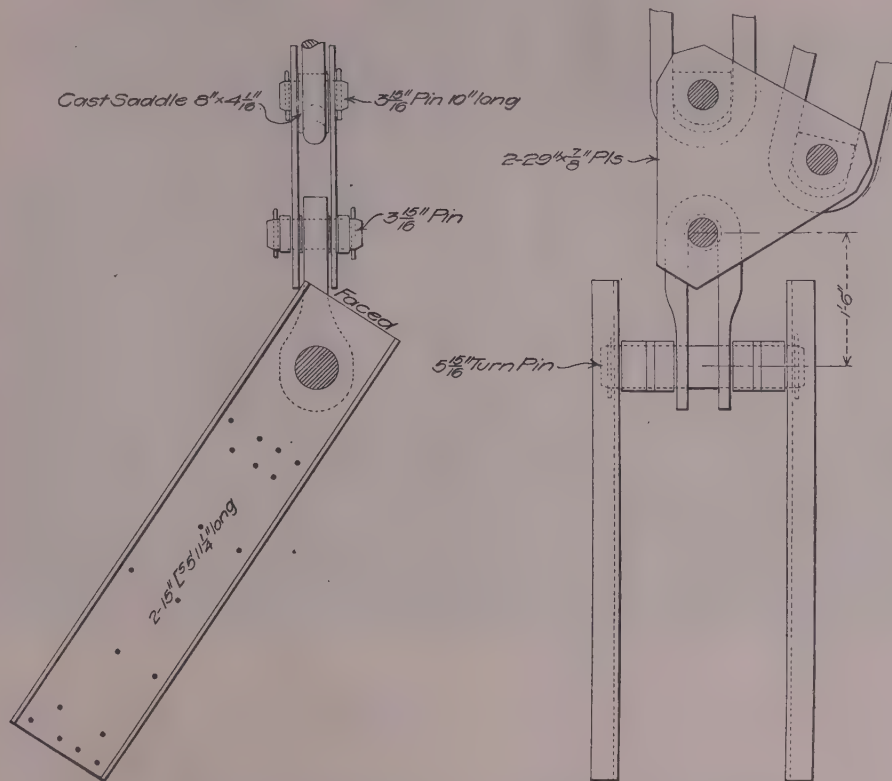
The attachment for the upper end of each lower post section had a pair of channels about 6 ft. long secured transversely to the center line of

the post by bolts through open holes in the ends of the post web, which were afterwards filled with field-driven splice rivets. The ends of the channels project beyond the face of the post and are connected by 9-in. pins about 4 ft. long, which engage 12x1 1/8-in. U-plates centrally spaced with filler rings between the channel webs. The upper ends of the U-plates are bored for 6-in. pins transverse to the large pins which receive triangular connection plates and short eye-bars like

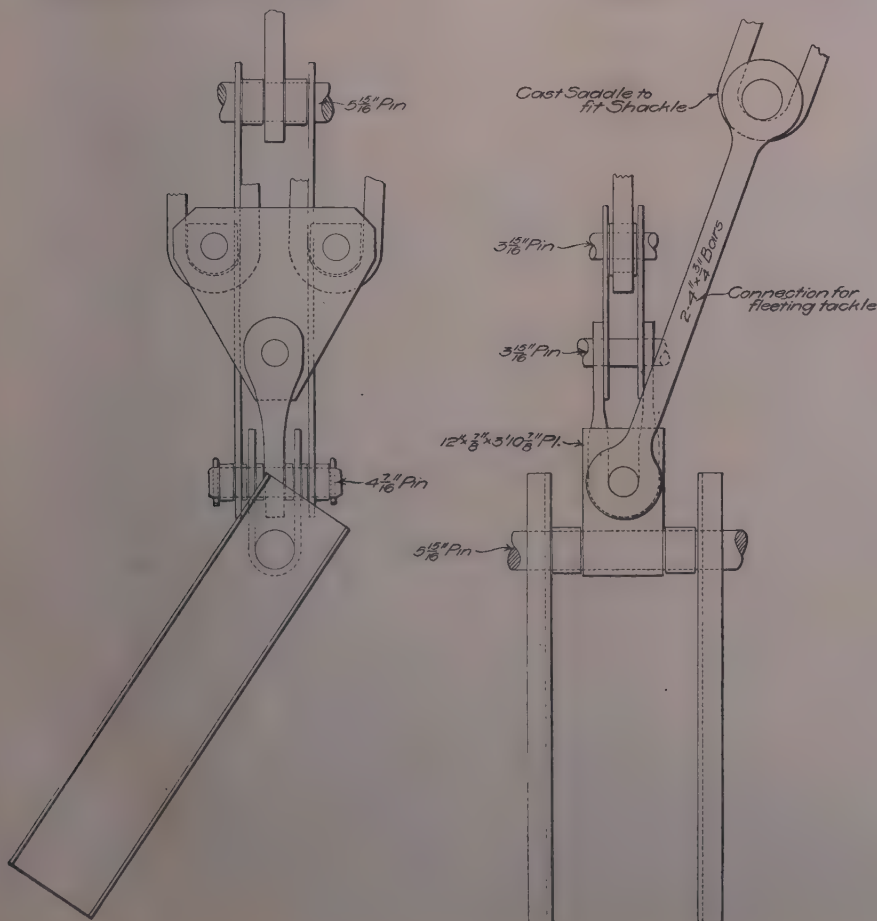
those described for the lower chord attachments. These devices have a capacity of 76 tons each. For the upper ends of the upper sections of the vertical posts, there were yokes, pin-connected through the main pin hole in the post and free to revolve around it as the post rose, thus allowing it to assume its vertical position. The yoke pin was provided with auxiliary short eye-bar attachments for the connection of a fleeting tackle. The hoisting attachment, being removed before the



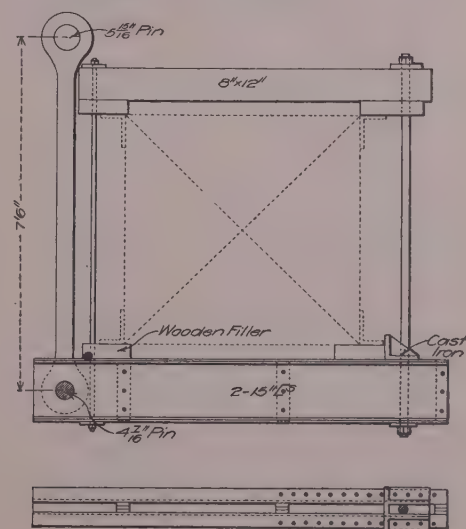
Attachment for Floor Beams.



Attachment for Each End of 100-Ton Bottom Chord Sections.



Attachment for Outer Ends of Lower Chord Sections A3 to A10.



Yoke for Turning Chord Section.

top chord and diagonal members were assembled to the vertical post, did not interfere with their connections.

The diagonal struts, sub-verticals and sub-diagonals were put in place with devices similar to those used for the vertical posts. All of the vertical and diagonal posts were hoisted in pairs, the corresponding members of both trusses being thus erected simultaneously by the use of four tackles for each member. The tackles were suspended from the jigger beams of the traveler in the planes of the trusses, and the lower blocks were pulled together to clear the trusses by means of transverse hand tackles fastened to the connections shown in the accompanying details. The two

pieces thus balanced each other and were hoisted clear of the truss until at a sufficient height to be assembled, when the transverse tackles were allowed to overhaul and the pieces swung into the required vertical planes.

The Washington Apartment House, Baltimore, Md.

The Washington Apartment House at Mt. Vernon Place and Charles Street, Baltimore, is



Limestone Wall being Placed around Reinforced Concrete Framework.

The efficiency of these different connections for handling and assembling the members and the value of the careful preparation and inspection of the members before erection, is shown by the great rapidity of the work. As much as 400,000 lb. has been erected daily on several occasions. The significance of this speed is illustrated by the fact that the steel handled was equivalent to the weight of ordinary 200-ft. span double-track bridges. In the summer of 1905, before the men were as thoroughly trained as at present, four sections of bottom chord together weighing 680,000 lb. were erected in one day, making the maximum tonnage so far accomplished. The speed of the erection has been very much diminished and its cost increased by the rigid requirement that all field-rivet holes shall be temporarily filled with service bolts. These are later replaced by rivets, mostly $\frac{7}{8}$ in. in diameter, of which 40,000 have already been driven.

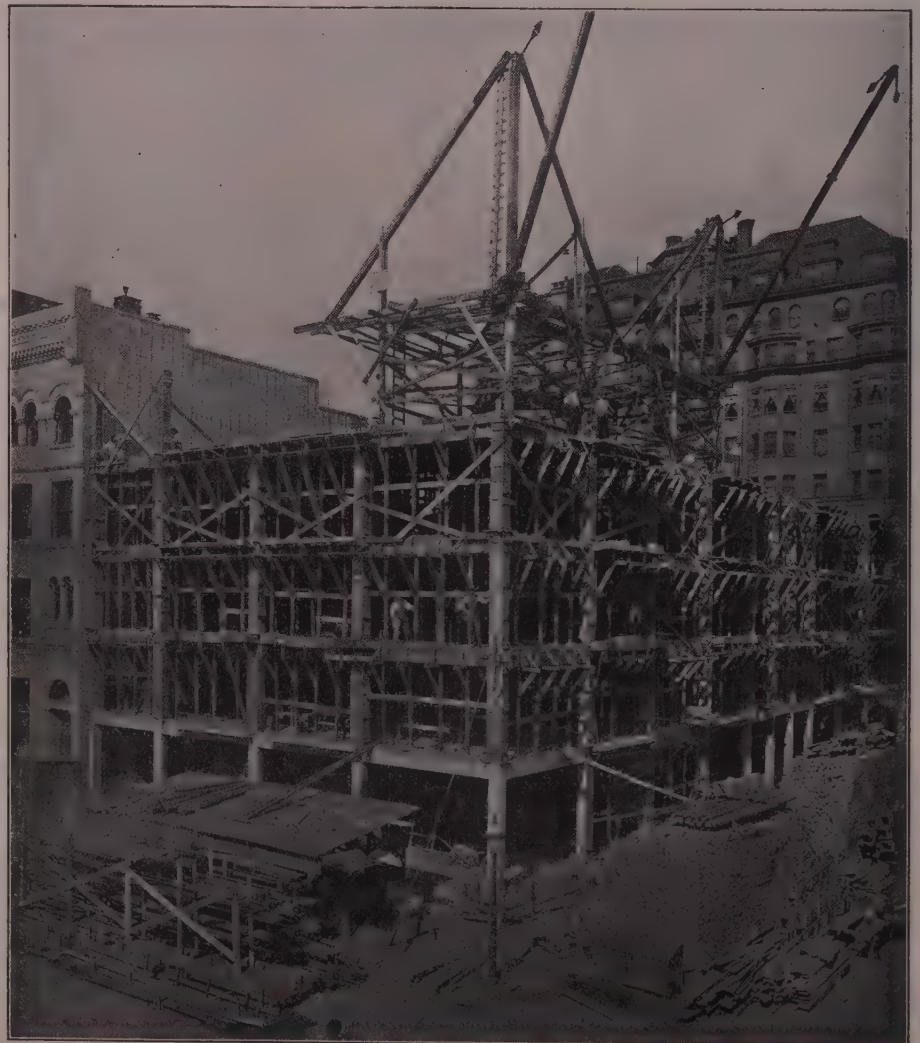
Mr. E. A. Hoare is the chief engineer, and Mr. Theodore Cooper consulting engineer of this structure. The contractor for the steel work and the superstructure is the Phoenix Bridge Co., Mr. John Sterling Deans, chief engineer; Mr. A. B. Milliken, superintendent of erection.

WORKING CONDITIONS IN JAPANESE MILLS are decidedly unlike those in this country, according to a report from Special Agent Graham Clark, of the Department of Commerce and Labor. There is no Sunday in Japan, but the first and fifteenth days of the months are holidays; all the rest of the time the mills run continuously. No stop is made for dinner, the hands taking 30 minutes off in rotation, and spare hands filling the places of those absent in this way. Each operative works twelve hours, with thirty minutes off. Fourteen days steady work is now recognized to be too much for average workmen, and the most progressive mills are allowing about one day in seven for rest. There are ten national holidays when all mills shut down.

a six-story building with a reinforced concrete skeleton and floors carrying the Indiana limestone walls at every story. It has extreme dimensions of about 68x158 ft., including two end wings 40 ft. wide which partly enclose a light court 72 ft. long with a wide center bay projecting into it from the rear of the main part of the building. The building is nearly symmetrical about the center transverse line and has 72 rectangular columns located from 5 to 16½ ft. apart in the clear. The floors are proportioned for a live load of 60 lb. per square foot plus the dead load, and the columns and girders are proportioned for maximum stresses of 350 lb. per square inch average compression in the concrete and 16,000 lb. per square inch maximum tension or compression in the reinforcement bars.

Most of the interior columns are approximately located in four longitudinal rows, but the arrangement is so irregular on account of the requirements for clearance of the partitions and corridors that many of them are offset from the general line, thus involving a lack of uniformity in the girders, which are sometimes carried directly by the columns and sometimes have one end supported intermediately between the columns on heavy girders. All columns are carried by reinforced concrete footings from 5 to 9 ft. square, which are seated on the sandy dry earth from 2 to 4 ft. below the basement floor and are proportioned for a load of 6,000 lb. per square foot. The footings are uniformly 9 in. thick, with vertical sides, above which the surface slopes about 2:1 to the center where the columns are seated on them with their horizontal bearings 6 in. below the cellar floor.

The columns are divided into ten classes, each of them proportioned for a different loading. All of the interior columns have square cross-sections



View Showing Derrick Tower and Construction of Reinforced Concrete Framework.

12, 14 or 16 in. wide in the basement, and are reduced to a uniform width of 12 in. in the upper story. They are reinforced with four or eight vertical bars from $\frac{5}{8}$ to $1\frac{1}{2}$ in. in diameter according to the stress requirements, the maximum being eight $1\frac{1}{2}$ -in. bars. They are proportioned for an eight-story building, of which six stories and the floor of the seventh floor have already been built. A temporary plank roof covered with slag has been made over the seventh floor and can easily be removed when it is decided to add the eighth floor and concrete roof.

All column bars are made in single-story lengths and are cut about 1 in. short of the ends of the columns where they engage vertical sockets made from 10-in. lengths of iron gas pipes built into the upper end of each column and serving as dowels to bond the successive sections together and center and splice the reinforcement bars. The rectangular wall columns have widths a little greater than their thickness and are in contact with the inner faces of the walls, from which they project like pilasters. Their construction is like that of the interior columns except for the dimensions of their cross-sections and reinforcement. The maximum is a 12x16-in. basement section reinforced by eight $1\frac{5}{8}$ -in. bars, and the minimum are the 12x12-in. columns in the sixth story reinforced by four 1-in. rods.

The beams and girders are of ordinary construction except that the reinforcement bars are spaced in the molds and firmly secured during concreting by stirrups of a special design used by the Baltimore Ferro Concrete Co. They are steel rods bent into double U-shape with the ends overlapping and forming saddles which are hooked to transverse rods permanently imbedded in the upper part of the floor slab or to the reinforcing bars of the slabs, binding the steel of the floor slab with the bars of the beams. The stirrups are proportioned as usual to provide for the stresses indicated by the shear diagram.

The construction was so irregular that special forms were built for each member, and after the concrete was set were taken apart and the materials used again and again for successive portions of the structure. The 1:2 $\frac{1}{2}$:5 concrete was made with Alpha Portland cement and screened 1-in. broken granite mixed in a Smith machine and handled in $\frac{1}{2}$ -yd. steel buckets by two stiff-leg derricks with 60-ft. 5-ton booms operated by Mundy hoisting engines. The derricks were seated on the tops of wooden falsework towers about 22 ft. square and 80 ft. high, located at the opposite ends of the light court so as to clear the finished structure and command all portions of it. Construction was commenced in June, 1905, and was completed in the following October. The principal quantities in the building include 4,000 cu. yd. of excavation, 1,500 cu. yd. of concrete and 164 tons of reinforcement steel. The falsework and centering, including the derrick towers, required about 150,000 ft. B. M. of timber, and the work was executed by an average force of 75 men.

Mr. William F. Cochran, Jr., is the owner of the building, and Mr. E. H. Glidden, was the architect. The Baltimore Ferro-Concrete Co., Mr. H. J. West, president, and Mr. Henri Kampmann, engineer and treasurer, were the engineers and contractors.

SNOW CLEANING IN OTTAWA, CAN., which was formerly carried on as a local improvement is now charged to the general expense fund. The snow is plowed from the walks with two-horse wooden snow plows, is thrown further into the roadway with "walkaway" plows, and finally is compacted with heavy wooden rollers. In the spring of 1905, according to the report of City Engineer N. J. Ker, on some roadways there was an accumulation of snow and ice 4 ft. thick, while the sidewalks were comparatively clean. *

The Sterilization of Sewage-Filter Effluents.

In the discussion of the degree to which it is advisable to purify sewage before discharging it into a neighboring water course, it is necessary to consider the aesthetic, economic and sanitary aspects of the subject independently, in order that the method of treatment may yield an effluent that is neither too good nor too bad for mingling with the natural body of water which receives it. Our first definite knowledge regarding sewage purification related to the most expensive of all methods, intermittent filtration through sand, and while it is admittedly the best method when properly managed with suitable filters, its cost and the great degree of purification both make it unsuitable for many cases. Fortunately other methods of treatment have been developed and studied since the intermittent filter was investigated in a scientific manner, and the action of the septic tank, the contact bed and the sprinkling filter, alone or in combination, is now almost as well known as the phenomena of the intermittent filter. The effluents from these later sewage works are not of pleasing appearance like the effluents from intermittent filters, but they have the great merit, as a rule, of being free from a tendency to putrefactive fermentation. In other words, they can be discharged into a body of water without causing offense.

The problem of sewage disposal, as now regarded, is one of preventing offence, and not of keeping a river or lake in a condition such that its water can be used for drinking purposes without purification. There is no longer a chance of preserving surface supplies free from contamination if they are obtained from populated drainage areas, and it is reasonable, therefore, to expect before long that an enlightened public sentiment will find expression in laws requiring the filtration of most surface supplies. Consequently the problem of sewage disposal becomes greatly simplified in most cases. From the aesthetic point of view, it is necessary to prevent the foul appearance and disagreeable odors which are evident in a polluted body of water. From the economic point of view it is necessary to prevent the contamination of the water with enough foul matter to make its purification for domestic purposes a difficult or expensive undertaking. From the sanitary viewpoint, it is necessary to prevent the pollution of a body of water to such a degree that its subsequent use injuriously affects public health. It is manifest that the sanitary and economical requirements are generally the same, because the ends of sanitation and economy are both served when the sewage is discharged in such a condition that it will not injuriously affect the subsequent filtration of the water. The new and rapid methods of sewage treatment answer all these requirements in most cases. They can be made to produce effluents which are reasonably clear and stable, although still germ-laden and potentially infectious; the discharge of such effluents into bodies of water will not bring about physical nuisance or economic damage, and so far as the use of the water for domestic and industrial purposes is concerned, this discharge is just and reasonable.

There is one aspect of the subject, however, to which it is unsafe to apply the above conclusions, namely, the discharge of effluents from rapid-speed works into waters from which shellfish are taken. The general testimony of those who have investigated the subject is that none of the rapid methods of sewage treatment remove much more than half of the enormous numbers of bacteria in the applied sewage, although they may furnish an effluent that is stable. Such effluents are unquestionably a source of danger if discharged into tidal waters containing shellfish, and consequently the time will come when it will be necessary to

prohibit the use of oysters and clams from such waters or else render the sewage discharged into them practically sterile. Sterilization in a satisfactory degree can probably be attained by careful intermittent filtration through sand or by the use of rapid methods of purification followed by some kind of sterilization. This last-named final treatment has received very little study and its value is questioned by some engineers, so attention is called to a valuable paper on the subject, communicated to the "Technology Quarterly" by Messrs. Earle B. Phelps and William T. Carpenter. The paper is quite long, but the main statements made by its authors concerning sterilization are summarized in the following notes.

Heat.—The use of heat has been suggested for the sterilization of sewage and effluents. In his testimony before the Royal Commission, Klein referred to a patented apparatus which he considers quite feasible, and by the use of which enough ammonia was to be recovered nearly to pay for the fuel required. There is no record that this device has ever been used on a large scale, and its claims are almost too fanciful. A rough calculation of the anthracite coal necessary to raise sewage to the boiling point from the average temperature of 60° F. gives 40 tons per million gallons, which will cost, say, \$4 per ton, or \$160. The total amount of free ammonia in a million gallons of Boston sewage is about 100 lb., which, if concentrated to the commercial strength of 28 per cent., would bring 40 cents per pound, or \$40. These are the most favorable figures possible, and in reality the revenue would be a much smaller proportion of the cost. Sterilizing by heat, therefore, will be a very expensive process and may safely be disregarded.

Lime.—Caustic lime acts as a weak germicide. The considerable removal of bacteria noted when lime is used as a precipitant for sewage is undoubtedly due to the action of the precipitate itself in dragging down with it the bacteria which it has entangled. Such an action is common in all precipitation, and even the sedimentation of sewage is always accompanied by a great reduction in the numbers of bacteria. For use with effluents, therefore, lime alone would not seem to be a valuable germicide. Rideal states that 60 to 70 grains (850-1,000 parts) are inefficient in sterilization. Thresh believes that lime would furnish a satisfactory sterilization of effluents, but has not tried it.

Acids.—Most bacteria are much more sensitive to acids than to alkalis. This applies particularly to the typhoid and cholera germs. Rideal considers it feasible to use acids as germicides. He states that Stutzer found 0.05 per cent. of sulphuric acid fatal to cholera in 15 minutes, and 0.02 per cent. fatal in 24 hours; that Ivanoff found that 0.04 to 0.08 per cent. destroyed the cholera germs in the sewage of Berlin and of Potsdam; and that Kitasato found 0.08 per cent. sulphuric acid fatal to typhoid in 15 minutes, a result obtained also by Rideal himself. To furnish one million gallons of sewage with 0.08 per cent. sulphuric acid would require 6,640 lb. of acid, at an approximate cost of \$332. Smaller amounts of acid might be used, since it would not be necessary to kill typhoid germs in so short a time as 15 minutes; but, on the other hand, there is in most sewage a considerable amount of free alkali requiring neutralization before any effect of the acid would be obtained. On the whole, this process would seem to be an impractical one except in cases of emergency.

Ozone.—Ozone has been used with more or less success in various parts of Germany, particularly at Weisbaden, for the sterilization of drinking water. Although the process has been most favorably spoken of by those in immediate care of the investigations, it has not generally been regarded as a success, and its use at Weisbaden has been

discontinued. There can be no doubt as to the possibility of procuring a satisfactory effluent by this process when the water in question is a highly polluted river water. Whether the process would deal satisfactorily with a sewage effluent of considerable turbidity has not been determined. Rideal points out that ozone is but sparingly soluble. Such being the case, it might altogether fail to penetrate the solid masses in the effluent, since the rate at which a dissolved gas will thus penetrate solids is a direct function of its solubility.

The principal cause of the failure of the ozone process, however, seems to be its expense. If this is the case in water works it seems hardly possible that the process could be applied to sewage effluents as an additional safeguard after purification. There are no data at hand for estimating the cost of ozone treatment when applied to effluents. Besides the cost of treatment there is the very considerable cost of installation of the necessary machinery and towers.

Chlorine.—Chlorine is well known as a powerful germicide. It has long been known as a bleaching agent acting upon organic coloring matter, not directly, but by means of the free nascent oxygen which it liberates from the water in which it is dissolved. It is probable that its germicidal effect is similar. In other words, chlorine and ozone come to the same thing in the end, namely, nascent oxygen. Chlorine, however, has the advantage of more ready solubility and of cheapness. It is used technically in three forms, all of which, however, act in the form of free chlorine, and not as compounds.

Until within recent years chlorine has been manufactured commercially by the Weldon or some similar process. In the Weldon process hydrochloric acid is made to react with a complex mixture of manganese hydroxide and lime—"Weldon mud"—the reaction being essentially

$$\text{MnO}_2 + 4\text{HCl} = \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$$
although in reality it is much more complex.

Recently, however, electrolytic processes have been developed by which the cost of manufacture has been materially reduced, particularly where cheap water power is available. The difficulties in the way of using gaseous chlorine are chiefly the cost of transportation, difficulty and danger in handling the gas, and the difficulty of accurately measuring the amount of gas added to the effluent. On the other hand, if the magnitude of the work would warrant the installation of an electric chlorine generating plant, there is reason to believe that there would be a great economy in the preparation and direct use of the gas, and the disadvantages noted would be obviated to a large extent.

Oxychloride or Hermite Process.—The electrolysis of ordinary salt yields chlorine and caustic soda. It is claimed that if magnesium salts be present, as in sea water, a secondary reaction occurs by which there are produced certain oxides of chlorine. Three oxides of chlorine are known: Cl_2O and Cl_2O_3 , the anhydrides of hypochlorous and chlorous acids, respectively, and chlorine peroxide, ClO_2 . The latter is formed only under exceptional conditions and is extremely unstable. The others unite instantly with water to form the corresponding acids. There seems to be no legitimate reason for assuming the presence of any compounds in this electrolyzed sea water except compounds analogous to those which we know are produced in the case of the sodium and the calcium salts; namely, hypochlorites. The hypochlorite of magnesium seems to be an unstable compound, readily hydrolyzing to magnesium hydrate and hypochlorous acid. This fact is sufficient to account for the higher disinfectant value observed in the use of electrolyzed sea water as compared with equivalent amounts of available chlorine in the form of bleaching powder.

Rideal made an extensive series of experiments

at Guildford, England, where he was able to test the effect of the "oxychloride" treatment upon raw and septic sewages and upon effluents of primary, secondary, and tertiary contact beds. The results, especially as regards the removal of *B. coli*, were all that could be desired. Examinations of the few organisms remaining in the sewages and effluents after treatment showed them to be largely organisms of the hay bacillus group, aerobic spore-forming bacteria, which are probably beneficial in the further oxidation of the organic matter. Absolute sterilization required very high concentration of chlorine.

Chloride of Lime.—Chloride of lime, so called, is a mixture of calcium hypochlorite, calcium chloride, and impurities. Its efficiency as a disinfectant is due to the action of the hypochlorite, which decomposes slowly, giving off oxygen and free chlorine. Thresh has used chloride of lime at Illford, England, for the sterilization of the effluent of a chemical precipitation plant. The addition of 140 to 200 parts of the chloride was found to give a nearly sterile effluent after the latter had flowed in a closed conduit for a mile. Commercial chloride in this country will average 35 per cent. available chlorine. Upon this basis the amount of chlorine used was 50 to 100 parts. The chloride would, therefore, seem to be as efficient as the so-called oxychloride, and in fact is probably a similar compound.

During the past year experiments have been carried on at the sewage experiment station of the Massachusetts Institute of Technology to determine the efficiency of bleaching powder in the sterilization of the effluent of a trickling filter. A preliminary series of tests was first made, covering a wide range of concentrations of bleaching powder. These tests were made in bottles. A strong suspension of bleaching powder was made up and analyzed for available chlorine by the arsenious acid method. Portions of this solution were then measured into bottles, each containing 1 liter of the effluent from the trickling filter. The available chlorine was again determined in a sample withdrawn from the bottle. Determinations of the total organisms present in the effluent before adding the disinfectant and at stated intervals thereafter were made. Plates were made with standard nutrient gelatin, incubated at 20° and counted on the third day.

The results indicate clearly the practical impossibility of obtaining a sterile effluent in this way. Neither the addition of large amounts of bleaching powder, up to 100 parts of available chlorine per million, nor the storage of the effluent for periods of time up to 20 hours proved entirely effectual. It is further shown that a concentration of about 5 parts per million of available chlorine and a storage period of about two hours give practically the maximum efficiency possible with the process.

Upon this basis, therefore, a practical test of the process was made. A large trickling filter at the Sewage Experiment Station, filtering raw sewage at the rate of 5,000 gal. per day, was used. A solution of bleaching powder was made up in a 50-gal. barrel of such strength that when added to the effluent at the rate of 2 gal. per hour it would supply the effluent with about 5 parts per million of available chlorine. It was not possible on such a small scale to regulate the flow accurately, and there was some variation in the amount of available chlorine found in the effluent. This value was determined each day when the samples were taken for bacterial examination. It averaged about 5 parts per million, and the variation was no more than may be expected in the case of a larger plant with less careful supervision.

The mixed effluent and sterilizing solution passed into a settling basin built on the principle of a Dortmund tank, and designed to give a mean storage of approximately two hours.

Regular examinations of the effluent before admixture with the sterilizing solution and after this 2-hour period of contact were made. The total bacteria growing upon gelatin at 20° were determined by the usual plating method.

The removal of total organisms was found to be 99.96 per cent. The determination of *B. coli* was made by the bile broth presumptive test recommended by Jackson (1906). Positive results were obtained in 33 per cent. of the tests made upon the untreated effluent at a dilution of 1/1,000,000, indicating that the organism was present on the average to the extent of about 330,000 per cubic centimeter. After treatment positive tests were obtained in 22 per cent. of 1 c.c. samples, indicating that on the average there was one organism present in 5 c.c. of effluent. Upon this basis the average removal of fermenting organisms (presumably *B. coli*) was 99.993 per cent.

A series of laboratory experiments was carried on at the same time to determine the germicidal power of the bleaching powder solution upon *B. typhosus*. Strong bouillon cultures of this organism were made in sterile tap water. After the number of organisms initially present was determined, suitable amounts of the bleaching powder solution were added, and determinations were made of the organisms remaining alive at stated intervals. Except in one experiment, the reduction in 24 hours is practically complete, and in two hours is satisfactory for all purposes for which such treatment would be undertaken, the enormous initial numbers being taken into consideration. The phenomenon of a few specially resistant organisms is a very common one in all investigations of germicides, whether of heat, cold, desiccation, or chemical disinfection, and is particularly marked here. The results of one experiment are in disagreement with the others. Whether they represent a specially resistant culture of the organisms or whether the results are due to some error in the experiment cannot be stated.

Summarizing, it may be said, as a result of these experiments, that a concentration of 5 parts per million of available chlorine from bleaching powder, acting for a period of two hours, will remove 99.96 per cent. of the total bacteria and practically eliminate the intestinal organism, *B. coli*, and any typhoid organism present.

Cost of Chlorine.—With the electrolytic process in use at Niagara Falls, where cheap power is available, the manufacture of chlorine and of bleaching powder is carried out very cheaply. Commercial bleaching powder can be purchased in the Eastern market at about 1 cent per lb., guaranteed 40 per cent. available chlorine. In other parts of the country the additional freight charges might make the cost somewhat higher. On the convenient basis of 1 cent the actual cost of the chlorine is 2.5 cents, and the cost of adding 1 part per million of available chlorine to the effluent would be 21 cents per million gallons, or \$1.05 per million gallons for 5 parts. Bleaching powder is made by the action of chlorine upon caustic lime, so that chlorine in this form will obviously cost more than as the free gas. To develop at once its full bleaching or disinfecting action it is necessary to use it in acid solution, as is done in commercial bleaching processes. An investigation of the reactions involved lead Messrs. Phelps and Carpenter to believe that the total available chlorine, as indicated by the analysis, is eventually set free in a solution of organic matter, such as sewage, especially in the presence of sunlight; but it is probable that the reaction proceeds more and more slowly as it reaches the end, and that in the time available for treatment it is not safe to count upon more than 75 per cent. of the available chlorine being actually used. Rideal observed

that there was an immediate loss of available chlorine corresponding roughly to the strength of the sewage or effluent under treatment, and that afterward the loss of available chlorine was very gradual, his explanation being that there were two distinct kinds of organic matter present. With the knowledge that free carbonic acid, always present in sewage, is able to react with the hypochlorite liberating chlorine, we are inclined to the view that the preliminary action noticed was due to this cause. Free gaseous chlorine, on the other hand, is all "available" and ready for immediate use. As the time element is one of immense importance in the design and cost of a sterilization plant, this item alone deserves much weight. Moreover, the use of chlorine gas possesses certain other advantages over the bleaching powder. It adds nothing else to the sewage, whereas bleaching powder adds a certain amount of insoluble material and considerable hardness. It seemed advisable, therefore, to obtain, if possible, some actual cost data on the production of electrolytic chlorine.

Through the courtesy of Messrs. A. G. Paine, Jr., president, and J. R. Crocker, superintendent, of the New York & Pennsylvania Company, the following statistics have been obtained, based upon actual costs in a large paper mill using the McDonald electrolytic cell. Each cell will produce 22 lb. of chlorine and 22 lb. of caustic soda per day of 24 hours, with the use of 2.08 kw. of current. One kilowatt-hour is therefore equal to 0.46 lb. of chlorine. The cost of power, made under the most favorable conditions by a modern compound condensing engine, burning "run-of-the-mine" coal at \$2 per ton, is estimated at not over \$52 per kilowatt-year, or 0.6 cent per kilowatt-hour. The cost of chlorine is therefore about 1.3 cents per lb., a trifle over half the cost of the chlorine in bleaching powder. If, as we have intimated, this form of chlorine shall be found to be 25 per cent. more efficient than the other, and if the original cost of installation be not too great, it seems that for large works, at least, the manufacture of chlorine might well be undertaken. Even at 2 cents per pound the cost of treating a million gallons of effluent with 1 part per million of chlorine would be reduced to 16.6 cents, or 83 cents per million gallons for 5 parts. Moreover, this expense would be considerably offset by the value of the caustic soda produced at the same time.

Copper and Its Compounds.—Rideal has experimented recently with copper salts, and finds them efficient in the sterilization of effluents. While its expense would seem to prohibit the general use of copper, it is undoubtedly a suitable disinfectant for water cress and oyster beds.

Johnson and Copeland (1905) obtained a reduction of total organisms in effluents ranging from 40 to 99.96 per cent., according to the amount of copper sulphate used and the period of treatment. They find action most rapid during the first hour. They estimate the cost of chemicals alone at \$5 per million gallons of effluent, treated with 10 parts per million, or \$10 for 20 parts, which they consider prohibitive. More experimental data on the use of copper salts are needed before we can judge of their value. Their effect will also depend largely upon the character of the water.

Miscellaneous.—Potassium and sodium permanganate have been used at times for the oxidation of organic matter in streams. At London sodium permanganate is added to the Thames regularly when it becomes too foul at times of low water. The application here is to destroy odors and putrescible material, but it undoubtedly partially sterilizes the water. Its use has been proposed for rendering effluents of chemical precipitation plants non-putrescible. The cost is greater than chlorine compounds, which would seem to be fully as efficient.

The Amines process was developed by H. Wollheim in England. It is claimed that trimethylamine treated with lime or other alkali produces a very poisonous substance. Herring brine is used for the amine. A large excess of lime is used, and the mixture used to precipitate crude sewage. Klein made a test of the process at West Horn in 1889, and found that a clear, non-putrescent, and sterile effluent could be obtained. Similar results were obtained at Wimbledon, where the bacteria on the sewage were reduced from 768,000 to none. The sludge is also non-putrescible. The process has never been developed further.

Conclusions.—Summarizing the more important points of the discussion, Messrs. Phelps and Carpenter state:

Ordinarily it is not the function of the sewage filter to remove bacteria from the sewage. In the case of the modern rapid filters, we are not at all certain as to the fate of the dangerous germs of disease.

Where extensive shellfish interests are at stake it will sooner or later become necessary to protect the neighboring waters from pollution, and in this case the total absence of pathogenic bacteria must be assured.

This result may be attained by the ultimate use of sand filters or by chemical sterilization.

Among the possible agents for use in sterilization, chlorine, either as chloride of lime or as free gaseous chlorine, appears to have the highest cost efficiency. An amount of the former which will yield 5 parts per million of available chlorine was found to have destroyed 99.96 per cent. of the total bacteria and practically all of the *B. coli* present in the effluent of a trickling filter treating crude Boston sewage, the time of contact having been two hours. The estimated cost of such treatment is \$1.05 per million gallons of sewage.

The use of gaseous chlorine, manufactured at the disposal works by electrolytic methods, would in the case of larger works considerably reduce this cost. An approximate estimate places the cost of such treatment at about 85 cents per million gallons of sewage, allowing 5 parts of chlorine per million. It is probable that the chlorine in this form is somewhat more efficient.

The process as thus outlined is entirely feasible, and in the case of large works it is cheaper than sand filtration. Further experiments upon a large scale are now under way to test the results of these experiments and to get more accurate cost and efficiency data.

Among other agents which may be used, copper sulphate seems to be the most promising, and further experimental data are needed to show what efficiency may be expected from its use.

Extinguishing a Burning Gas Well.

Extinguishing the burning gas well which was delivering over a million cubic feet of gas per hour at a pressure of about 600 lb. per square inch was accomplished last winter at Vanderpool Well No. 1, of the New York Oil & Gas Co., near Independence, Kan. The well had been drilled to a depth of about 1,500 ft. and there was in the hole about 360 ft. of 8¼-in. casing when the gas was struck. The gas was, in a measure, unexpected, and certain fittings not being on hand it was decided to tube the well with 6-in. pipe and set a packer. When 1,100 ft. of 6-in. pipe were in the well and its closure seemed certain, a severe electrical storm occurred and a flash of lightning ignited the escaping gas. Forty feet of 6-in. pipe had been left extending above the ground and from the top of this there rose with a great roar a jet of burning gas 150 ft. high, which destroyed the derrick over the hole immediately. According to Mr. W. M. Welch, superintendent of main lines for the Kaw Gas

Co., the reflection of the flames on the clouds at night, could be seen fifty miles, and with a favorable wind the roar could be heard for ten miles.

The problem included not only extinguishing the flame, but also preserving the well so that the gas could be finally controlled. Nine boilers, such as are used in connection with oil-well drilling outfits, were collected and eighteen 2-in. jets of live steam at a pressure of about 120 lb. per square inch were simultaneously turned on the flame in an attempt to smother it. No impression was made and the scheme was abandoned. The two joints of pipe projecting above the ground were removed by throwing a line round the top, bending the pipe to one side about 45 deg. and then unscrewing it close to the ground with the same line. The 1,100 ft. of pipe hanging in the well was supported by "elevators" or clamps fastened around its top and resting on the top of the 8¼-in. pipe. The flames which passed through the 6-in. pipe formed the main flame, but in addition flames came up between the two pipes, and being deflected by the clamps shot out and prevented near approach.

It was determined to cover the well with a conical hood, through the top of which the flames could pass until the bottom should be made tight when the top could be closed and the flame extinguished. This plan was finally carried out successfully, but not until numerous unsuccessful attempts had been made and considerable special apparatus destroyed. The cast-iron hood finally used was conical in form, 3 ft. in diameter at the base and about 6 ft. high. In the top was fixed a 12-in. gate valve upon the stem of which was fastened a reel wound with flexible wire so that two men running out with the end of the wire could quickly close the valve. A crane built of 6-in. steel pipe with a mast about 50 ft. high and a boom about the same length was placed so that when the boom was swung over the well the hood would come directly above the opening. Means were provided for controlling the motion of the hood in all directions. The clamps holding the 6-in. pipe were then pried off and the pipe slipped down, causing the flame to issue solidly from the 8¼-in. casing. This made it possible to approach the well with screens and dig a saucer-shaped cavity around it, which was made muddy so that the bottom of the hood might be submerged. The latter was then lowered to place and the flame shot through the gate valve. The bottom of the hood was made tight with successive layers of earth and canvas kept thoroughly wet and wire cables were thrown over the hood and fastened to dead men buried deep in the ground. When all was ready the men who were to shut the valve were given the signal to run. The attempt was successful, after five weeks of effort and the flame went out. Less than ten seconds later the gas broke through under the hood, but the fire being extinguished, closing the well was then an easy matter.

THE HIGH-PRESSURE WATER SYSTEM for the fire protection of Winnipeg, Can., is equipped with four sets of double-acting three-throw pumps, each having a capacity of 1,800 imp. gal. per minute against a pressure of 300 lb. per square inch, and with two sets each able to deliver 900 gal. per minute. These pumps are operated with three gas engines, one of 540 h.-p. and two of 270 h.-p. each, all using producer gas. The air-compressing plant and storage tanks are in duplicate and are so arranged that the whole plant can be started within one minute after an alarm has been received. The heavy cast-iron mains, 20 in. in diameter, have been laid in the principal business districts and are constantly kept charged with water. The pumps were made and erected by Messrs. Glenfield & Kennedy, Ltd., and the engines and producer plant by Messrs. Crossley Brothers, of Manchester, Eng.

The Trainshed of the Lackawanna Terminal at Hoboken.

The train shed for the new Lackawanna passenger terminal at Hoboken, N. J., designed by Mr. L. Bush, chief engineer of that railroad, is an entirely new departure from what has heretofore been considered the standard type of structure for this purpose, in that it consists essentially of a series of short-span longitudinal sections each of which cover two tracks and is just high enough to clear the largest Lackawanna locomotives. At the time this type of shed was adopted, considerable comment was made on its design, with a somewhat general impression that the proposed construction would be open to serious objections. All of the shed excepting one bay has been completed and has been in service for nearly a year, during which time its efficiency has been fully demonstrated.

The general plan of the terminal and the improvements connected with it have been described in various articles in this journal, the design of the train shed having been quite fully taken up in the issue of June 24, 1905. The shed is built of structural steel, reinforced-concrete and wire glass, with the steel protected from locomotive gases by concrete and with copper flashing where required. It is 607 ft. long and consists of six longitudinal sections, each with a total width of 43 ft. 4½ in., one section 35 ft. 10 in. wide and one 30 ft. 4 in. wide. Each wide section covers a pair of tracks, 13 ft. apart on centers, the platforms between the pairs of tracks being 20 ft. wide; the two narrower bays cover one track only. The roof of the sections is carried by a longitudinal row of columns, spaced 27 ft. apart on centers down the middle of each platform. A transverse built-up roof girder is placed at each transverse column row and between these girders the roof is carried directly by longitudinal steel purlins riveted to the girders. The portion of the girders directly over the smoke stacks of locomotives on the tracks and the purlins on both sides of longitudinal openings in the roof are incased in concrete.

These longitudinal openings in the roof extend the full length of the shed, one over each track. A built-up steel section incased in a concrete slab, 5 in. thick and 4 ft. 4½ in. high, is placed on each side of the opening to direct the gases from the locomotive stack out of the shed, to protect the steel work and to avoid rain and snow being blown in on the platforms. These vertical concrete slabs project about 1 ft. above the top of the roof. Not only are gases and exhaust steam from the locomotive completely and successfully carried directly out of the station through these openings between the slabs, but a considerable portion of the heat radiated from the locomotives also passes out through them. The closeness of the roof to the ground might be considered to be liable to cause the shed to be warmer in the summer than is the usual type of high long-span shed. Experience during the past summer has demonstrated the reverse conditions to exist, however, as simultaneous temperature readings made in this shed and in a large shed of the regular type not far distant showed the former to be at least from 3° to 5° cooler than the latter, which difference is evidently due to the ventilation secured by the openings in the roof. It is also very noticeable that none of the annoying and disagreeable echoes from the exhaust of engines exist in this shed.

The objection that snow and rain would blow through the openings on the platform was also raised when the design was proposed. No difficulty has been experienced from this source, as the vertical concrete slab on both sides of each

opening is so arranged as to prevent practically any possibility of snow or rain reaching the platforms. During the past summer, an unusually heavy rain storm accompanied by a high wind blew water through the openings in sufficient quantity to cause it to run off the sides of the car roof in such manner that some of it spattered on the platforms near the cars. The fact that such a storm will occur not more than a few times a year at the most makes such a result a very minor objection when considered with the valuable features of the shed.

The good lighting of the interior of the shed and of the cars on the tracks is one of the excellent advantages of the construction. The roof consists of a concrete slab, 2 in. thick, which is reinforced with expanded metal. Three continuous skylights are placed longitudinally in the roof of each section. Two of these skylights are over each platform and are each 8 ft. wide; and the third skylight is over the longitudinal center line of each bay and is 3½ ft. wide. These skylights are of the Anti-Pluvius type and are glazed with Mississippi wire glass. The skylight at the peak of the roof admits light to the inside windows of the cars on the pair of tracks below. The other two rows of skylights

A system of steam pipes in a turntable pit has been found to keep it completely free from snow under any conditions and enables a saving in cost to be made as compared with handling snow from these pits by manual labor.

Aside from the comfort and convenience to the traveling public which this shed provides, its construction has proved much more economical and at the same time better adapted to the site than the ordinary form of high, long-span shed. In fact, the uncertain conditions of the site would have occasioned no small amount of difficulty in securing suitable foundations to carry the trusses of a large shed. Furthermore, a heavy passenger traffic had to be taken care of on the site of the train shed while the latter and the platforms were being constructed. The ordinary long-span type of shed could not have been erected on the site without serious interruptions of traffic and interference from the falsework required for its erection. The entire erection of the steelwork of the present shed was handled with one ordinary derrick car and possession of only two tracks at any one time was required during the progress of the work. The ease with which this new type of shed can be kept clean and the saving in the cost of maintenance as



Steel Frame of Hoboken Train Shelter, Lackawanna R. R.

over the platforms, admit light to the outside windows of the cars and to the platforms. This arrangement of skylights has been found most satisfactory, and more complete lighting is obtained over the whole interior of the shed than could be secured by any method in the usual type of shed.

The run-off of rain water from the roof is carried to a wrought-iron down-spout in each of the hollow cast-iron columns by a copper gutter placed over each longitudinal row of columns. The roof is pitched slightly toward the line of the transverse rows of columns, which pitch, together with that in both directions from the longitudinal center line of each section, carries the water quickly to these down-spouts. A pipe supplied with steam is placed over each gutter in order that the snow may be melted and carried to the down-spouts, if found necessary, thus avoiding any necessity of shoveling. That this arrangement for melting snow will work has been demonstrated successfully in connection with the pits of turntables at different points on the Lackawanna in which difficulty has always been experienced heretofore with snow.

compared with the difficulty and cost of maintaining a shed with single, long, high, truss spans of steel subjected to the effects of engine gases are important features of this type of construction.

No difficulty was experienced in the construction of the shed. Owing to the necessity for maintaining traffic, the work had to be carried on in such manner as to leave a sufficient number of tracks entirely free for train service. The piles carrying the platforms and the shed columns were first driven over most of the site; then the platforms were built in such order as could be followed. The steelwork was nearly all erected before much of the work on the concrete roof had been done.

The concrete was made in Smith mixers set up on gondola cars. The mixer car and a string of four to six cars of concrete materials were set on the track directly under the point where concrete laying was being carried on, and were moved forward as the work progressed. The concrete materials were handled from the cars to the mixer in wheelbarrows on plank runways laid on the tops of the cars. The con-

crete was placed from a working platform swung from the steel work.

The forms for the concrete were all hung from the steelwork of the roof frame, no trouble being experienced in their construction or erection. They were built in sections and were torn down and used repeatedly. The working platforms also being hung from the steelwork no centering was required and the tracks under the section on which operations were in progress could have been made free for service at any time if the necessity had arisen.

The only change in the entire design found necessary during construction was to increase the thickness of the vertical slab on each side of the opening over the tracks from 4 in. to 5 in. in order to permit the concrete to be placed around the reinforcement with greater ease. A wet 1:2:4 mixture of cement, sand and broken stone was used for the concrete. In order to produce concrete that would flow around the expanded metal and the steelwork $\frac{3}{4}$ -in. broken stone was used instead of cinders.

The shed was built by the regular forces of the Delaware, Lackawanna & Western R. R., under the direction of Mr. L. Bush, chief engi-

Notes on Foreign Pavements.

Last summer Mr. B. T. Fendall, city engineer of Baltimore, was authorized to visit a number of cities in England and on the Continent for the purpose of personally examining the paving methods and results attained there. The plan outlined was: First, to see the work actually in progress; second, to learn the source from which the paving materials were obtained; third, to ascertain the cost of the materials and the expense of maintaining the pavements examined; fourth, to estimate the suitability of such pavements and paving methods for Baltimorean conditions. His report on this investigation has just been received, and from it the following notes have been taken:

London.—Most of the paving in London, Westminster and Holborn is sheet asphalt or wooden blocks. There is some granite block and some macadam, but only laid to meet special conditions. The sheet asphalt is a natural rock asphalt found in Sicily, Switzerland, parts of France and Germany. The principal sources of supply are from the mines of Val de Travers, Switzer-

sheet asphalt, and, in Mr. Fendall's opinion, is not in any way suited to Baltimore. The cost would be much greater than the cost in London, due to the fact that the material must be transported a much longer distance.

Wooden blocks appear to be the favorite pavement with the London engineers. Two kinds of block are used, Australian hard wood, untreated, and soft pine impregnated with creosote. The Australian woods are jarrah, karri and tallow woods. Jarrah and karri are species of eucalyptus. In appearance they are much like mahogany, but much harder. The tallow looks like old, thoroughly seasoned oak. There is a very wide difference of opinion among the engineers as to the merits of the several kinds of pavements. The engineers of London and Westminster favor the soft pine block treated with creosote, whereas the engineer of Camberwell prefers jarrah. The jarrah has not done as well in London and Westminster as soft pine. The edges and corners crumble and the blocks wear round, making the street unpleasant to drive over and bad for horses, whereas the pine blocks wear down much more uniformly. The engineer of Camberwell does not experience this trouble, and states that the reason jarrah does not do well in London is because the blocks are laid with open joints, to provide for swelling when they take up moisture; that in Camberwell they lay a tight joint, giving the blocks a thin coat of hot tar on the sides, as laid, and on the top after they are in position, and by thus keeping the moisture out there will be no swelling. He says that before the top coat of tar wears off the fibers are so compressed by traffic that the blocks will not take up moisture.

In laying the wooden blocks much the same methods are followed as in America, except that they finish their concrete with a flush coat of cement and sand, and we use a mixture with much less water. They pour the joints with tar and sprinkle small particles of broken stone or gravel on the tar. The stone is driven into the wood by street traffic, and renders it less slippery. In rainy weather the wood block pavements are sprinkled with bits of stone as occasion may require to reduce the slipperiness, which is a source of trouble and is expensive.

There are some granite block pavements in the business section of the city on and near the water front, where heavy and slow-moving teams are used, around markets and on heavy inclines. It is of a higher grade than any block pavement Mr. Fendall has seen in America. The blocks are better made and show closer joints, and the pavers who lay the blocks are better mechanics than our men. The usual practice is to fill the joints as far as practicable with small broken stone or clean gravel and then pour in hot tar; the whole surface is then covered with fine broken stone or small gravel, and the traffic forces it into the joints, giving a better surface in the beginning, and preventing the blocks from wearing round. Some of these block pavements are laid on concrete foundations and some on sand and gravel. Where concrete is used a sand cushion or a mortar bed is laid on the concrete.

There is nothing unusual about the macadam used in London. The practice is to lay 6 in. of broken stone in two courses of 3 in. each. The first course is composed of stone that would pass a 2-in. screen and be rejected by a $1\frac{1}{2}$ -in. screen. It is spread evenly, kept wet, and rolled with a heavy roller until it ceases to "creep" in front of the roller. On this is laid 3 in. of stone of varying sizes, from $1\frac{1}{2}$ in. to almost powder. This second course is also thoroughly sprinkled and rolled. If there is an insufficient amount of fine material to properly bind the coarser stones, sand or crushed screenings are added. After the last rolling the street is well sprinkled with water and thrown open to traffic. The sprink-



View in Completed Train Shelter, Hoboken Terminal, Lackawanna R. R.

neer, and under the immediate supervision of Mr. E. I. Cantine, division engineer. The structural steelwork was fabricated by the Fort Pitt Bridge Co., of Pittsburgh.

SAND IN THE WATER SUPPLY of the city of Evans, Colo., has been overcome by a method described as follows by Mayor John H. Behrens. The supply was drawn originally from an 8-in. well sunk 108 ft. deep into a stratum filled with soft water. The water rose in this casing within 10 ft. of the ground surface, and was drawn from it with a large pump. The latter was so powerful that it sucked sand into the cylinder, where serious trouble was caused. A concrete curb or well, 12 ft. in diameter and 36 ft. deep, was then sunk and four 6-in. wells were driven in its bottom to a depth of 106 ft., into the stratum containing soft water. The bottom of the curb or well was then concreted to keep out the hard surface water, and the 6-in. pipes were cut off about 6 ft. above this concrete bottom. The water issues from them freely into the large well, which serves as a suction chamber for the pump. This method of obtaining the water has prevented all the former troubles with sand.

land, and Seyssel, France. The method of laying is first to prepare a foundation of concrete with a smooth, flush coat on top; on this is laid a coating of asphalt rock about 2 in. thick. The rock for this top coat is first reduced to a powder and heated. It is then brought to the street hot, and laid much in the same manner as "topping" in asphalt pavements is laid in America. After the hot powder has been laid to a proper thickness, it is then tamped with hot iron tampers, either round or square, about 40 to 50 in. area, and weighing 20 to 25 lb. It is then rolled out with a light hand roller and smoothed and ironed out with hot irons especially designed for the purpose. The pavement when so laid is more durable than our asphalt. Mr. Fendall reports, and when repaired the patches are neat and look well. The objection to the pavement is its extreme slipperiness. To overcome this trouble the surface is frequently sprinkled with coarse sand. This sand helps to a certain extent when first applied, but, under heavy traffic, soon works into mud, and is most disagreeable for pedestrians crossing the driveway. It also adds very materially to the expense of street cleaning. The cost is greater both for construction and repair than

ling of the macadam goes on continually except during rainfall. The repairs are made in a very simple way. When a hole develops it is slightly loosened at the bottom with picks, new stone filled in, and the traffic soon does the rolling, rendering the patch as hard and compact as the remaining portions of the street. When the holes become very frequent, covering 20 per cent. of the whole surface, the street is resurfaced. The top course is loosened up with picks, the material so loosened screened and put back, together with as much new material as may be necessary, the whole sprinkled and rolled as when originally laid.

The city of London proper is making some experiments with asphalt blocks. These are so entirely different from those used in Baltimore that they may be considered as an entirely different class of pavement. The blocks are 10 in. square on their surface and $2\frac{1}{2}$ in. thick, $1\frac{1}{2}$ in. of which is natural rock asphalt and the lower portion of which is cement and sand. They are laid on a $5\frac{1}{4}$ -in. concrete foundation with $\frac{3}{4}$ -in. mastic covering, the joints poured with a specially prepared tar or mastic. Shortly after the traffic is turned on the street the joints close up and the pavement has the appearance of sheet asphalt. The pavement is largely an experiment, and the engineers and inspectors did not appear to be enthusiastic over it.

Hamburg.—Hamburg is a city with some rather sharp inclines, and a class of traffic over its streets much like that of Baltimore. The paving materials and the methods of laying their pavements are about the same as in London. The engineer of Hamburg was not especially in favor of wooden blocks for general use. He had streets laid with the soft wood, treated with creosote, and some laid with the Australian hard wood, untreated. While not condemning the hard wood blocks, he was not prepared to give them an unqualified indorsement, as his experience was limited. His position with respect to wood blocks was that the pavement was desirable about hospitals, schools and other places requiring an absence of noise.

Hamburg has some sheet asphalt on its principal streets, where the grades are flat and the traffic light, but its use is not general. The materials most used are granite blocks for heavy traffic on business streets, and macadam for light traffic in the residential sections. The granite block pavements in Hamburg are the best Mr. Fendall has ever seen. The blocks are cut in a most perfect and satisfactory way, and when laid with that care and accuracy with which the Germans do all of their work, the resulting pavement is most excellent and as good as it is possible to make such a pavement. The blocks are generally cut square on the surface, tapering slightly downward, so as to get the arching effect. As in England, they are sometimes laid on concrete and sometimes on sand and gravel, as the judgment of the engineer may decide. The filling in of the joints with gravel and tar is considered vitally important, and a specially prepared tar is used.

The macadam is usually gravel, 20 centimeters thick, laid in the usual layers, sprinkled and rolled, and is quite satisfactory.

Berlin.—Berlin is a city of low grades. The surrounding country is flat, and the streets are only given sufficient incline to provide proper drainage. Asphalt is the favorite pavement, laid in the same way as in London. The concrete is usually gravel, that material being cheap and plentiful, large quantities being obtained near the city. At many bridges the inclines approaching the bridges are comparatively sharp (about 2 per cent.), on which inclines wood blocks are used. When frequently sprinkled with bits of stone the street is less slippery and easier on

horses than the sheet asphalt. Treated soft wood blocks are not in general use, but some have been laid as an experiment. Of the hard, untreated woods, preference was given to tallow wood. The engineer in charge was not prepared to either recommend or condemn hard wood pavements, as he had not collected sufficient facts to express a definite opinion.

At the suggestion of Consul-General Thackara Mr. Fendall visited Charlottenburg, a suburb of Berlin, to see a special sort of stone pavement which was being constructed there on the Kurfürsten Dam. This pavement was constructed of small blocks of stone laid on a well-rolled sand and gravel foundation. The blocks showed nearly square faces of about 2 in. with a depth of from 2 to $2\frac{1}{2}$ in. They were carefully set by hand, rammed by a one-man rammer, and the joints filled with clean, dry sand. The pavement when completed had much the appearance of a mosaic floor. It is pleasant to drive on, looks well, but must be expensive, and the probabilities are that it is not durable, except under very light traffic. Such a pavement would be quite impossible in Baltimore, there being no stone near by that would break in the shape necessary. Mr. Fendall saw some sidewalks laid with this same class of material, different colored stones being used, and the mosaic effect more fully developed. All very pretty, but of no practical use to Baltimore.

Dresden.—Dresden is a clean, well-paved city, with more macadam than in Berlin in the residential sections. The streets were built on sharper grades, as the natural surface was more rolling. On all such grades a good stone block was used. They had experimented with an asphalt block much like those used in Baltimore, but they were not considered satisfactory. The methods of laying and repairing are substantially those in use in London. Mr. Fendall saw some asphalt being laid on what was to him a new plan, but learned later a similar method had been long used in Paris and Vienna for sidewalks and was known as "coulé." It is rather simple and consists of an asphalt mastic in which sand and a small gravel were mixed. It is laid quite hot and very soft and pressed down by wooden trowels. That which he saw was laid in two courses of about 1 in. each. The material was mixed at the contractor's plant and brought to the work in specially designed iron wagons, so arranged that the heat was kept up, and as the wagon moved the mixing continued by means of a sprocket and worm gearing attached to one of the wheels, by which means the material went into the street in substantially the same condition as when it left the plant. All of this character of work that he saw was used in repairing a street railway track, which had been previously laid with sheet asphalt. He does not recommend what he saw as desirable for Baltimore.

Vienna.—In Vienna Mr. Fendall found granite block, sheet asphalt and macadam pavements. Their methods do not vary from those already described. The work of which Vienna is doing a great deal is widening, straightening and regrading its old streets. These streets were built up centuries ago, when the city was a walled town. They were narrow and not graded at all. They simply followed the natural contour of the ground. All of this is being changed to meet twentieth century requirements. New street lines have been established, and whenever a house is rebuilt, so much of the lot as is necessary is acquired by the city and the house built to conform to the new line and grade. As a result of this, parts of some of the streets are quite irregular. On one, he noticed that the property had all been acquired on one side and it had been graded and built on proper lines; the opposite side only partly so. The change in grade required a cut of 15 or 20 ft. A retaining wall was built to hold

up the old street and the new was graded and paved 20 ft. below. Sooner or later the whole street will be built up and all houses conform to the new lines. In the meantime no one seems to be seriously inconvenienced and business is progressing satisfactorily. If a property owner feels that he has been injured, and cannot agree with the city as to the amount of damage, the courts are open to him, but he must show real injury before he can recover.

Budapest.—Budapest is one of the few cities in Europe using any asphalt pavements laid as in America. It is an experiment with them, but they are not getting good results. The asphalt they use comes from deposits in Hungary and appears to be of excellent quality, but they do not seem to have learned just how to manipulate it in order that they may get the best results. Budapest also uses the rock asphalt and wooden blocks. Many streets are paved with stone blocks, and this is the pavement recommended by the engineer. The block used is basalt and comes from quarries nearby and is brought in by water. Several pieces of pavement laid with specially selected block are perfect, and the average stone block paving is good. The methods used in laying and the prices paid for the various different pavements is about the same as the other Continental cities.

Munich.—Munich has some excellent pavements. Asphalt, stone block and macadam are most used; very little wood block has been used. The streets are kept cleaner than in any other city visited. Much of the work of street cleaning is done by women and boys. The American Consul told me there were most excellent arrangements in winter for removing snow. A snowfall of 12 or 15 in. is not unusual, and is removed from the principal streets in from two to three hours.

The paving is done on the lines heretofore described. For macadam, gravel is used almost entirely. The city owns some excellent gravel pits, and the gravel is gotten out by endless chain dredges, screened and stored in bins, and moved to the streets when needed by wagons.

Paris.—Here Mr. Fendall found the same asphalt, wooden block, stone block and macadam, but he was disappointed in the condition of the streets. Many of the principal streets needed repairs and some renewal.

The feature of special interest in connection with the paving problem in Paris is the city's plant for the preparation and treatment of wooden paving blocks. The plant appeared to him absolutely perfect. The city buys lumber in the open market and cuts it into blocks. The blocks are then treated with from 6 to 7 lbs. of creosote, to the cubic foot and used on the streets as required. The timber used is greatly inferior to Georgia pine, and the amount of creosote used is much less than we use, only one-half, but the blocks are cut more accurately to the required size, and when laid show a better surface. In addition to turning out new blocks they bring partly worn blocks from the street to the plant, where they are sawed off and shaped up so that they may be used again in some street where the traffic is light. This shaping up of old and partly worn blocks is also done in the borough of Camberwell, London, where the jarrah blocks are mostly used.

The plant in Paris is capable of turning out about 180,000 blocks per day. The motive power is electricity generated by dynamos driven by a 240-h.-p. engine. The waste lumber, sawdust and old blocks feed the fires under the boilers, and little if any fuel is purchased. In addition to the machinery for making the blocks the plant is equipped with lathes, planers, drills, saw sets, emery wheels for sharpening saws and all things necessary for the repairs of the plant. The saws are equipped with excellent safety devices

to prevent the possibility of injuring employees. The plant is lighted by electricity, and if necessary, may be run day and night. In addition to the plant being well designed, it is splendidly handled, kept scrupulously clean, no waste of any sort, and any city, even so great a city as Paris, should feel a certain pride in such a plant.

Liverpool.—Liverpool has to meet conditions much the same as Baltimore. The city is hilly and the traffic heavy, as well as of considerable volume. The paving most used in the business sections is granite block paving. The blocks used vary in size on different streets. On the street running parallel with the Mersey, over which the heavy traffic from the docks moves, the blocks used are substantially the same as those now used in Baltimore, laid on a 6-in. concrete base, joints filled with small gravel and tar and the small gravel covered over the top. On other streets, carrying lighter traffic, smaller blocks were used and in many instances laid on sand. The small blocks were of various sizes and showed a square face on top. Some streets had blocks 6 in. square and 7 in. deep, and on other streets they were as small as 3 in. square on the face and 6 in. deep. Intermediate sizes were used on other streets as the engineer considered desirable. The small square blocks made quite a smooth street under light carriage and wagon traffic, and some of them had been down for 15 or 20 years with a very low maintenance cost.

Not much asphalt or wooden block is used, and neither pavement seemed to be in favor with the city authorities. Some of the cobblestone streets (they have considerable cobble in Liverpool) were being improved with Trinidad asphalt, using the cobble as a foundation in the place of concrete. This plan was being pursued on streets with a flat crown, suitable for an asphalt pavement, and at the very low cost of \$1.75 per square yard, with a ten-year maintenance guarantee. Many streets were macadam and several, tar macadam. These tar macadam streets in Liverpool were the only ones Mr. Fendall saw either in England or on the Continent which were in any sense successful. They had only been laid about 18 months, but were in excellent condition. The method of laying them was simple, almost crude. The plan followed is to lay and roll 3 in. of coarse stone or gravel, cover with a coat of tar, then 3 in. of finer stone or gravel rolled well, and another and somewhat heavier coat of tar, then a topping of finer material about an inch thick, another rolling, and the street was ready for use. The cost was small, 75 to 90 cents, but how long the pavement will last is unknown. That it was good after 18 months, with no bad symptoms, looks promising, and the engineer believes it will be a success. The character and quality of the tar used is undoubtedly the reason for its being so much better than the other tar macadams Mr. Fendall saw. The engineer said that he and his chemist had been experimenting on various tars and mixtures for several years, and they thought that they had solved the problem and gotten a tar that would meet their requirements. This same tar they use for filling the joints of their granite blocks.

THE INSTALLATION OF BLOCK SIGNALS on the Lake Shore & Michigan Southern Ry. has now been completed from Buffalo as far west as Toledo, 123 miles having been put in during the past season. The signals are of the automatic electric type of the Union Switch & Signal Co., using storage batteries, which are charged from 15-h.-p. gasoline engine charging stations located at intervals of about 15 miles. The average length of signal blocks is about one mile.

Safety in Concrete Construction.

Presidential Address of Richard L. Humphrey before the National Cement Users Association.

We are indeed in the age of cement and it is apparent that this infant industry which burst its swaddling clothes but a few years ago, has become a lusty youngster—its growth outstripping the dream of its most ardent supporters. We are passing through an era of unparalleled prosperity which has occasioned an activity in the world of construction demanding enormous quantities of cement, thus advancing the yearly consumption to figures which are a hundred-fold greater than those of a dozen years ago. When Germany, our principal competitor, topped a yearly production of 20,000,000 barrels, we regarded it as wonderful, yet a half dozen years later our own production has doubled these figures and we now are the largest cement producing country of the world. It is hard for even the cement user to follow the meteoric progress of the production and consumption of cement. A progress so rapid that the friends of this material of construction must needs pause and consider the danger which may await a too rapid pace.

It was my pleasure a year ago to address this Association on the development of the industry and to indicate some of the uses to which cement was put. I shall utilize the time allotted for this address in pointing out the features of the great test—the San Francisco earthquake—which served to further establish some of its intrinsic qualities as a building material and to further point out some of the abuses to which it is subjected, which often result in failures of the structures in which it is used and which tends to retard the progressive development in its use. As I took occasion to remark a year ago, cement has its weaknesses and limitations and these should be faced squarely by its advocates and pointed out emphatically, thereby preventing abuse which tends to dim its unsurpassed qualities. Of the materials of construction cement it is at once the most delicate and the most valuable—a plastic material, whose properties we are only just beginning to appreciate and understand. Its extensive use is not because its qualities are well developed and recognized, but because its cheapness renders it an effective competitor of other building materials both in strength and fire resisting qualities.

Great catastrophies and overwhelming disasters of all kinds, while resulting in great hardship and suffering, teach lessons of incalculable value. On the 18th of April of last year the entire civilized world stood aghast at the appalling destruction which visited the city of San Francisco and vicinity—the result of a slip of the earth's crust. To the constructor and user of the materials of construction the most interesting feature was the behavior of the various materials of construction under those unusual and rigorous conditions. This was a test of such unusual violence that only the structure begotten of first-class materials and design and honest workmanship could survive. Flimsy and loosely erected structures were shaken to the earth and collapsed like houses of cards under the terrific wrenching and shaking of the earth. Those structures which survived the earthquake test were, in many cases, subjected to a fire test exceeding in extent in its intensity all the great conflagrations of recent years. Many structures which successfully withstood the first test failed signally under the test which followed by reason of the inadequate fireproofing. Other structures failed under both tests, while a very few withstood both tests successfully.

The study of the relative efficiency of the various materials of construction under these condi-

tions is most interesting. It is a generally accepted fact that no structure can withstand the stress produced by the movement of the earth on the "fault line." The effect of the shaking and vibrations of the earth in the territory affected could be resisted, and the secret is proper design, first-class materials and honest workmanship. In tall structures rigidity of construction and stiffness, the result of adequate wind and portal bracing, is absolutely essential. While reinforced concrete structures in the zone of seismic disturbance were few, these passed the test in a highly satisfactory manner. Rigidity and stiffness and a high fire resistance which are inherent qualities of this material demonstrated how admirably they were suited to resist this extraordinary test.

This test seems to be greatest for structures built in low lands—on alluvial soil in the valleys of rivers—where the settlement of the earth under the earthquake vibrations was very great. On solid ground and rock formations the test was much less severe. Structures at points of great destruction such as Palo Alto, San José, Salinas, Santa Rosa, etc., were built on soft material as indicated. The buildings of Stanford University suffered severely, most of the buildings being wholly or partly destroyed by the earthquake shock. The types of construction represented were stone, brick and stone veneer and concrete—the latter not being reinforced except at the floor lines. The buildings of the latter type passed the ordeal successfully and demonstrated the superior qualities of a material possessing great adhesive qualities. The great concrete dam at Crystal Springs reservoir gave additional proof of the substantial qualities of concrete for, although within a few hundred feet of the fault line, it suffered no damage.

At Palo Alto and Santa Rosa the failure of concrete block buildings has been pointed out as examples of the failure of cement to withstand the test. At Palo Alto three cement block buildings collapsed. No other result could have been expected when the method of construction is considered. The blocks were laid up without a tie of any kind, and the floor joists and roof timbers either rested on or were built into the wall without any tie. Under the movements of the earth the walls were pushed out of line, the wooden members of the structure not being tied to the walls, there was no means of restoring the wall to its former position and it collapsed. In one of the buildings the gable end of the roof rested against the wall and served as a battering ram.

That such structures can be so built as to withstand earthquake shocks is evidenced by the building at Santa Rosa also built of cement blocks, but differing from those just referred to in that iron tie rods held the walls tightly to the floor joists and roof timbers. While the neighboring brick, stone and frame structures collapsed, this building was but slightly damaged along the cornice line. The destruction at this point was perhaps as great as that in any part of the territory affected by the earthquake. At Mills College, just outside of Oakland, there were two structures of concrete, one a bell tower 80 ft. high with 4-in. walls of reinforced concrete, and the other a building with walls of concrete reinforced at the floor lines only. The former was not damaged in any way. The latter building was but slightly damaged by the collapse of the chimneys, which crashed through the roof and floors.

Another reinforced concrete structure was the Cyclorama in Golden Gate Park, which demonstrated the futility of attempting to successfully provide against earthquake shocks where the foundation is bad and the materials poor. The walls of this structure rested on a foundation made by leveling off the top of Strawberry Hill;

the aggregate of concrete consisted of a hard shale which made a very inferior concrete, and a careful inspection of the ruined structure shows that little else could have been expected under the conditions.

In San Francisco proper, in the fire zone, the behavior of concrete was equally satisfactory and there are many cases where concrete successfully passed both the strength and fire tests. There were but two structures of reinforced concrete, namely, the Bekins Van & Storage building and the Academy of Sciences. The former was in process of erection and had reached the second story, while the latter was an old structure. The walls of each structure were of brick and were cracked extensively by the earthquake, while the concrete remained undamaged, both structures being completely burned out, but the concrete was not damaged in the slightest degree. The columns in the Academy of Science building were cast iron, filled with concrete, and in one instance where the cast iron expanded and failed by cracking the concrete core remained uninjured.

Cinder concrete was most generally used for floor construction and behaved in an entirely satisfactory manner.

I think to the unbiased observer concrete gave sufficient evidence of its ability to resist both earthquakes and fire; its rigidity making it an admirable earthquake material, while its extremely low rate of conductivity for heat makes it a fire resistant of high order. The San Francisco earthquake, with the resultant conflagration, will be of inestimable value for the future constructor in furnishing reliable evidence of the value of the various classes of material, and the record is but another testimonial of the admirable properties of cement. Its strength and durability, its cheapness in comparison with other materials of construction places it in a position in which its future is absolutely secure. We are not fully conversant with its properties, its strong and weak points, and it behooves us to go slow and not be precipitate in its indiscriminate and reckless use.

The bold design in reinforced concrete, when taken in connection with the lack of a definite knowledge of some of the factors required in such design, is venturesome to say the least. Nor is this venturesome spirit confined to reinforced concrete alone. Plain concrete is used under conditions requiring reinforcement and building blocks are used for purposes to which they are utterly unsuited and under conditions which are dangerous.

Wherever failures occur, it is generally cement that has to bear the blame. And on this material all the sins of omission or commission are heaped, and yet it should be noted that it is extremely rare that failures are traceable to the quality of the cement used. Where an unbiased examination is made, the failure is generally found to be due to bad workmanship, improper design, insufficient strength and a too early removal of the forms for the construction of all of these, and many failures occur from improper material, insufficient mixing, improper consistency for effective tamping. In these days of machine mixing too little attention is given to the rigorous inspection of the process. As an illustration of this point I would state that on a large piece of work the system used in the mixing of the concrete was such that the sand was thrown in by one man, the crushed stone by another and the cement by a third, the latter being called away from his post failed to perform his part, but during the interval the sand and stone went in with rhythmic precision. It is obvious what the effect of these batches of concrete would be and how fatally they would affect the strength of an important part of the structure. In another case which I have in mind the cement, sand and stone were fed automatically from hoppers

so adjusted as to give the requisite proportion. At the time of this inspection the cement hopper had choked, but the sand and stone were flowing on and the operator who was totally unaware of the fact, remarked, when his attention was called to it that he thought the concrete looked rather peculiar. Perhaps the greatest source of failure is the strength of the forms; too little attention is given to the design of these forms and they are often made entirely too light for even normal conditions and where a temporary load in excess of that for which the structure was designed comes upon it the structure is either dangerously strained or collapses. I have in mind cases where excessive quantities of cement have been stored on the green concrete structure, and in one instance producing a collapse of the floor panel.

Concrete of improper quality is often used and I recently saw in New York cinder concrete consisting of one part of cement and five parts of cinders going into a reinforced concrete structure. Again the length of time which should elapse before the centering is removed has a marked bearing on the question of failures. The time required for concrete to harden sufficiently to permit the removal of the forms is naturally a variable one, depending on the design, the weather condition, and the strength of the concrete. A concrete with a small percentage of cement will require a longer time to acquire the requisite strength than a richer mixture; it will also take concrete longer to harden in cold than in warm weather and a beam of long span must be stronger than the one of short span before the form can be removed.

Another source of failure is the lack of attention to details, especially as regards connections in the erection of a structure. The structure may be properly designed with the requisite amount of steel, yet the structure may be fatally weakened by the character of the connections. A reinforced concrete structure should be practically a monolith—the tension members must be continuous in beams and columns. It makes a material difference as to the length of the splice allowed in such columns or whether the splice in continuous beams is adequate. I have in mind an instance which came to my notice of an enterprising laborer who, observing the rod in a column projecting out of the concrete in the column of a several story building, seized a sledge hammer and drove the bar down flush with the surface of the concrete. The remedy for all this is inspection, most careful inspection.

No more unstable material is in use to-day than cement. From the moment it is reduced to an impalpable powder it undergoes changes which seriously affect its quality. Unlike steel, wood, or similar materials, it does not stay tested and its quality must be ascertained before use. When we consider the way in which so delicate a material is handled by unskilled laborers it is not surprising that failures should occur. A steel beam or channel is fabricated at the mill and undergoes during the process of manufacture a most rigid and careful inspection; and in the erection again undergoes careful inspection. On the other hand a concrete structure is fabricated on the site and is subject to little, or at the best, indifferent inspection and the unintelligent laborer contributes to the abuse. The same careful and rigid inspection should be given the erection of a concrete structure as a steel structure receives and until this is done we may expect failures.

The comparatively few failures in concrete structures are allowed to overshadow the great number of excellent examples of well-designed constructions of this class. And it should be noted that what failures there are, occur during the process of erection and are almost invariably due to a too early removal of the forms or bad workmanship. The failure of a structure of con-

crete by reason of improper design, bad workmanship or poor materials no more affects the value of concrete for constructive purposes than the failure of a structure of steel due to similar conditions should condemn steel for structural purposes. We may expect failures as long as incompetent men will undertake to design structures in concrete and unskilled and ignorant persons will attempt to "skin" the work for the purpose of increasing their profits; and it will only be the continual loss of life that results from these failures that will bring the authorities to such a realization of their responsibilities as will result in laws which will properly safeguard the public.

Amid the ignorance and wonder that attends the use of a new material the charlatan practices his art unchecked, new forms of patented construction are constantly springing into existence, many absolutely devoid of merit, and the public are being proportionately humbugged and deceived. Plans and specifications are generally prepared by the contractor and for every skilled competent contractor, there are many who are incompetent, who do not hesitate to skin the work in order that they may finish it without loss of profit, having taken it at a figure entirely too low to admit of proper workmanship with first-class materials. Such practices are wholly unnecessary, for first-class legitimate construction can successfully compete with other forms of construction and there are many reliable concerns capable of executing such work.

Owners, architects and engineers are criminally responsible where they award work to irresponsible contractors lacking in the requisite experience and knowledge for safe construction, or who permit structures to be erected under the direction of competent persons who do not give the work their personal supervision. Where the charlatan reaps his greatest harvest is through the medium of the beguiling literature giving strength values based on tests primarily made for the purpose of developing and exploiting the strongest features of the system for which he holds the patent. Many concerns rush in with inadequate experience, acquiring this at the expense of their clients.

The present condition of the art of concrete or reinforced concrete construction is not unlike the condition of the iron business in its early history, not so many years ago. The knowledge relating to the construction of highway bridges was at that time largely vested in the contractor and it was the practice for the contractor to submit bids for bridges based on his own plans and specifications. The number of failures of highways was directly attributable to this fact, and it finally drove the constructor into making his own designs and specifications, with the result that the contractor bid much more closely and intelligently on a definite plan and specification, and failures in such structures became largely a thing of the past.

This experience, I believe, will be repeated in the case of structures of cement. In the meanwhile a knowledge of the properties of concrete is more fully established, its strong and weak points more thoroughly understood; it behooves us to go slow and be more conservative and careful in its use. The failures which occur from time to time unquestionably hinder the development of the industry in that they cast doubt upon a comparatively new material and make builders cautious in its use. I would repeat that we should recognize the weak points of cement and further see to it that its good points are not abused. It will only be by determined action that the present abuses can be curbed and the fair name of concrete preserved.

It is the duty of every user of this material, of every friend to join most heartily in the cause. Let each of us put our shoulder to the

wheel, thereby controlling this rapid movement in the application of cement to constructive use, lest it get away from us and run on to destruction. We should not be afraid to state the truth, even though it hurts; we should by all means be honest, and not hold malice toward those who frankly call our attention to the few weaknesses in the most magnificent building material at the command of the constructor.

Book Notes.

About four years ago a review was printed in this journal of "City Roads and Pavements," by Mr. William Pierson Judson, a book that is unusual for the large amount of information it gives in concise form. It was primarily intended as a practical guide for the authorities of cities of moderate size, and the recent appearance of a third and revised edition shows that the need for such a volume is a real one. The preparation of streets for pavements, the placing of concrete foundations, and the respective fields of usefulness and methods of construction of stone block, wood, brick and asphalt surfaces are fully explained. The information about laying foundations is particularly good. The most generally useful feature of the book, however, is the detailed description of telford and macadam road building, which presents very clearly the fundamental principles of such work and explains the various steps of construction by a collection of excellent illustrations. (New York, Engineering News Publishing Co.; \$2.)

The numerous letters received regarding recent statements in this journal on the value of water powers can be answered in considerable part by reference to Mr. Alton D. Adams' "Electric Transmission of Water Power." It is a book which explains clearly the reason for the rapid increase in value of such powers, since electricity has furnished means of transmitting their energy. So long as they could be utilized only in their immediate vicinity they were generally of trifling importance, but now that it is profitable to transmit 500 h.p. a considerable distance and sell it away below the cost of steam power people are beginning to take notice of little streams again. The difficulty most civil engineers have in looking into the subject is that the electrical books furnished them for guides are full of all sorts of strange terms introduced since they closed their Ganot and began active work. They do not wish to penetrate the special field of the electrical engineer, but they have a deep desire to keep in touch with the actual results their electrical confreres can produce. This is the information Mr. Adams supplies. He starts with a statement of what is being done in the way of developing water powers and transmitting their energy electrically, and then explains the financial attractiveness of such propositions. The cost of conductors for transmission is discussed with the aid of data from sixteen plants with lines from $4\frac{1}{2}$ to 142 miles long, and then comes a chapter explaining the relative advantages of direct and alternating lines under different conditions. The discussion of the physical limits of transmission which follows is interesting rather than valuable to those readers who are mainly concerned in estimating the possibilities of small powers. The development of water-power for electric stations, to which Mr. Adams next turns, is particularly instructive when presented, as in this case, in comparison with old methods before electric transmission was practicable; this chapter will be particularly useful to those who are inclined to estimate the cost of utilizing water

powers to-day with the aid of cost data from plants twenty years old. The leading aspect of the subject is elaborated in greater detail in the following chapter on the location of power stations. The general arrangement of stations is next taken up; the points of similarity in modern stations of the same general type are pointed out, and there is a table of dimensions and capacity of twelve stations of 800 to 41,000 kw. capacity. The three chapters immediately following describe the design and use of generators, transformers, switches, fuses and circuit breakers in recent stations, and while the information is doubtless very elementary to the electrical engineer it will unquestionably be helpful to the civil engineer. The same may be said, also, of the chapters on the regulation of transmitted power, guard wires and lightning arresters, cables, conduits, pole lines and many other subjects in the last third of the volume. The book answers a decidedly important want at the present time, and the profuse illustrations in it are in themselves of much value as furnishing examples of the latest hydro-electric engineering practice for large and small powers. (New York, McGraw Publishing Co.; \$3.00.)

In the four years that have elapsed since the first edition of Mr. James E. Homans' work on "Self-Propelled Vehicles" was reviewed in these pages there has been a great change in motor cars. The unusual types have almost disappeared, mainly because they were poor, but in one or two cases because men hesitated to buy an automobile differing materially from those owned by his acquaintances. Once in a while a much-derided design has been introduced in the face of general ridicule, but it has been no easy undertaking; the people who now look with envy on the Cadillac business should recall the early difficulties Mr. Murphy and his associates had in establishing that unique "one-lunger" now so popular. In consequence of the rapid change in cars and their details it has been necessary to revise the book just mentioned from time to time, and a sixth edition is now out. At a hasty glance, the reader who has kept in touch with automobile development will be a little disappointed, for the first thing seen on looking into the book are many pictures of practically obsolete cars and details, which appeared in the first edition. A little further examination will show, however, that there is really a good reason for the retention of this antiquated material. In rewriting the book, the author has generally stated at the beginning of each chapter the particular problem presented in designing the part under consideration, and has then enumerated the possible methods of solving it. Each of these methods is discussed in turn, and in this way the reader is put in possession of all the essential facts concerning the reasons for the designs now in use. A large amount of information concerning cars built seven years ago, which appeared in the early editions, has been omitted from the latest, and the author has very wisely used pictures wherever possible to explain his ideas, rather than text which is more troublesome to understand. Attention is called to this characteristic of the book because the numerous old engravings in it are rather misleading until the text is examined. On account of the rapidly increasing use of motor cars by engineers and contractors, it is in place to give a rather more comprehensive notice of the book than is customary in the case of new editions. After a brief historical sketch there is a three-page chapter ending with a statement of thirteen essential elements in a satisfactory car. This early statement of the different points to be considered should be firmly fixed in the mind of every amateur driver, for if this is done he will then be

able to fill in the details of the subject on a logical foundation instead of having a lot of miscellaneous information about radius rods, clutches, and other things swashing around in his mind in an undigested mass sure to ferment in time and make trouble when he is fifty miles from home and his gasoline is running dangerously short. Most of the trouble an amateur encounters in understanding his car is due to his desire to learn all about it in fifteen minutes; that idea must be abandoned for the one presented by Mr. Homans. The author begins his detailed explanation of a car with the differential system on the rear axle or on the jack-shaft in the case of side-chain cars, and then takes up chains and propeller shafts. Next he explains the construction of the front axles and steering gear and has a good deal to say on side slip. Springs and underframes are taken up in the next chapter, and the relation between pneumatic tires and springs is explained. Wheels are next discussed and then tires, including the troubles of the pneumatic type and the methods of caring for them. Up to this point, the text applies equally well to gasoline, steam and electric cars, but the remaining subjects must necessarily be discussed separately under those three heads. The next chapter is accordingly on the general features of each type, the merits of the steam car being stated by Mr. Windsor T. White, those of the gasoline car by Mr. Elmer Apperson, and those of the electric car by Mr. Walter C. Baker. The twelve succeeding chapters are on gasoline vehicles. The theory of heat engines is briefly described and then the parts of a gas engine are explained. Four-cycle and two-cycle engines are explained, and the author states that the perfection of a two-cycle motor for cars is a matter of careful design. Although but one American company has had enough success with the type to continue its manufacture for several years, there is abundant testimony to the good service given by its cars in competent hands. A special chapter is devoted to the exhaust, in which brief mention is made of compound gas engines, although no mention is made of the American car using such a motor in a very successful manner, in spite of the financial troubles of the company making it. Water and air cooling are explained in separate chapters, and that on water cooling is very meager in view of the importance of the subject and the amount of mechanism it requires. The notes on air cooling are also inadequate, particularly as the best results with this system are attained on American cars, but one of which is illustrated. The description of carburetors is also unsatisfactory in its lack of illustration of many leading types, which is to be regretted because the amateur generally has considerable difficulty in understanding them. While the principles on which they operate are satisfactorily explained, their details surely ought to be illustrated more fully. The chapter on ignition is mainly valuable for its explanation of magneto and dynamo machines and recent devices connected with them, and is decidedly deficient regarding induction coils and different methods of wiring, although in a subsequent chapter a little more information on this very important subject is given. The balancing of engines is explained, and the reason for the sweeter running of six-cylinder engine in comparison with motors having fewer cylinders is stated. The control and governing of gasoline motors is described fairly well, and there is a very good chapter on the care and operation of gasoline vehicles. The final chapter of this section of the book describes the clutches and transmissions of leading cars. Space prevents any other mention of the parts devoted to steam and electric cars, than a general statement that the information is hardly so well arranged as in the first part. The book closes with chapters on brakes, ball and

roller bearings, and lubrication. As a whole it is a very fair statement of the general features of motor cars, written in such a way that little technical knowledge is required to understand it. (New York, Theo. Audel & Co.; \$2.)

Letters to the Editor.

VIBRATIONS IN WATER FALLING OVER DAMS.

SIR:—In your "Letters to the Editor" will you kindly put us in the way of finding out how to abate the following nuisance: The water falling over a dam 150 ft. long in our neighborhood causes such a vibration in the air as to set the doors and windows in most of our houses shaking and slattering. What is the best way to arrange flashboards on the dam to avoid this annoyance and serious distress to sick and nervous people? Are there other cases on record of such troubles and were they remedied? Any information you can give will be most thankfully received.

Respectfully yours, GEORGE A. TROY.
South Framingham, Jan. 12.

[This trouble has occurred at a good many places, although it is not a common one. The vibration is probably due to a partial vacuum behind the falling water, for it has always been relieved by furnishing a free inlet for air between the downstream face of the dam and the sheet of water passing over it. The reason the trouble does not occur more frequently is that such an opening for the ingress of air is provided in most dams by the structural design to answer other requirements. In some cases all that has been necessary was to provide a few flashboards on top of the dam, so as to prevent the sheet of water passing over in a long continuous mass, and in other cases some heavy timbers rigidly attached along the face of the dam so as to break up any vacuum were sufficient. The best remedy in any case can only be determined by a study of all the conditions.—EDITOR.]

TITLES OF ENGINEERS.

SIR:—Will you be good enough to let me know if there is any uniformity of practice that you have been able to discern in the titles of engineers occupying positions below that of chief engineer? Some of the engineering employes of this company are inclined to squirm under the rule of this company that there shall be no titles given to subordinates or used by them save "member of mechanical engineering department" or "member of civil engineering department." We have a chief engineer who reports to me directly and has under him an architectural division and a civil engineering division; we have also a mechanical engineer, whose duties are essentially those of a head designer of our product; and a general superintendent, who not only is in charge through his assistants of the shop organization but is also responsible for the design and management of our power plant and transmission system. When our company grew so large that it was necessary to have manufacturing establishments in several cities widely separated from each other, we thought it would be a good plan to decide what would be the best organization of our entire technical staff. Our chief engineer, mechanical engineer and general superintendent are, as you know, men of the highest rank in their respective branches; and many of their assistants are also rapidly rising into prominence. Our business policy, however, is to keep all individual names from appearing in connection with our work so far as possible, which practically means never. Some of the younger technical men are inclined to think that this is a great injustice, and that they should be allowed to state to the

world that they are in charge of some particular branch of one of the departments, when this is the case. If we did not employ technical men except in strictly engineering positions possibly our directors would agree to the wishes of these younger people, but as a matter of fact a very large proportion of our best technical men are employed in the shops or as salesmen. We find that their technical knowledge there is worth a great deal more to us than in the offices, provided they have the real "mixing" qualifications which enable them to meet people easily and talk to them forcefully. In our opinion these men, while acting as foremen or selling agents, are using their engineering knowledge to a little better advantage to the company than if they were in charge of some small branch of our designing or construction departments. It is a fact that we have much more trouble in filling their positions than in getting men for places under our chief engineer or mechanical engineer.

We aim to keep all our men happy and contented so long as they stay with us. Of course we cannot provide places for all of those whose abilities are such that they deserve better things, but so long as an engineer is with us we wish to have him contented. A few of my acquaintances in other lines have suggested that we can keep some of these people longer by giving them titles and allowing them to take some credit to themselves for the good work they are doing. For reasons stated above, this seems to me to be a poor policy with us, and it occurs to me that your acquaintance with numerous organizations will probably enable you to help us out with information as to the views held elsewhere.

Yours truly, GENERAL MANAGER.
Cleveland, Dec. 14.

[There is absolutely no uniformity regarding the titles of different engineering positions. In the larger manufacturing corporations, which absorb a considerable number of technical college graduates each year, the policy is almost everywhere that stated above. In two cases which have come to the attention of this journal, young engineers in places of moderate responsibility have assumed to place on their business cards, fictitious titles which might mean much or little, and as a result the financial improvement in their salaries has been rather slower than with others holding equally responsible places. The prevailing opinion among such companies is that everybody must merge individuality in the organization as a whole.

On railway organizations, where the rate of pay is rather low, it is customary to use more titles than among other private corporations, but it is interesting to observe that the titles of high positions on one road may be used for low positions on another, so that they really mean very little, as honors. In public organizations, titles are given more freely than elsewhere, in all probability, for it is felt by the chief engineers that the tenure of office of their assistants is probably so short that the men are entitled to get everything out of the work in the way of honors and reputation that they can legitimately obtain.—EDITOR.]

ROCK TUNNELING.

SIR:—Can you or your readers explain why it is that there has been no material saving in the cost of rock tunneling in this country in the last twenty years or so? I have recently been looking into this subject in connection with a report on tunnels for both mining and railway interests that supplied data from their own experience, which went back many years. The great improvement in mining machinery and explosives, the use of steam shovels for loading spoil, the general improvement in working conditions through the adoption of electric light and better

mechanical apparatus should have more than offset the increased wages of the men and their shorter hours of labor. It manifestly has not, however. In some reports on recent rock tunneling in Europe the costs are given in such a way that it is impossible to analyze them, but assuming that they allow for a reasonable charge for plant they are certainly below what we are doing in this country. Moreover the rate of progress on some of the longer foreign tunnels is enough to make us take a way-back seat. We have nothing to show in comparison with some of the progress records per day and per week on the Simplon tunnel, for example.

It seems to me that this is a subject deserving careful investigation. Tunneling in rock is bound to be an important feature of engineering work in other lines than mining. Until very recently most engineers would go to almost any length to avoid a long rock tunnel for a railroad line, not only because of its high first cost but also on account of the troubles in operating trains through most tunnels. This bad opinion is now disappearing. The people who put up money for most new railway lines are able to spend whatever is needed to get the right location at the outset and so the subject of first cost has ceased to be all-important. The older lines are driving more tunnels in their rectification work and thus showing by their experience the value of tunneling freely on original construction. This is a condition in but one branch of civil engineering. The same willingness to undertake heavy rock tunneling is seen in places on water and sewerage works where pumping would have been resorted to a quarter century ago. Consequently it seems to me that a thorough analysis of the changes in the items of cost in rock tunneling should furnish much valuable information and possibly indicate in what directions our methods may be improved, so that the European rate of progress and low cost may be attained here. In order to secure the most voluminous and reliable data it would probably be best to have some society appoint a committee to take up the subject in a thorough and comprehensive manner.

Yours truly, X.
St. Louis, Jan. 10.

SIX REMARKABLE GATES have been delivered to the Roosevelt dam works for use on the bypass tunnel around the dam, through which water will flow for irrigation purposes. The gates will be arranged in pairs, so that two must fail at once in order to derange the operation of the system. Each gate covers an opening of about 5 x 10 ft., and operates under a pressure of about 800,000 lb., making them the largest gates operating under a pressure of anything like this amount. On account of the salt in the water, all faces in contact and the rollers on which the gates operate are made of special bronze, selected after numerous experiments to determine the best composition and increased in strength by working it under a steam hammer. The gates were designed by Mr. F. H. Teichmann, and have been provided with a special lifting device designed by Mr. O. H. Ensign. It consists of hydraulic cylinders working under a pressure of 700 lb. per square inch, with operating valves driven by electric motors controlled from a power station several hundred feet distant. The position of the gates at any time is indicated by instruments on the switchboard of the station. The gates were made by the Llewellyn Iron Works, of Los Angeles, and as many of the pieces weigh 8 to 10 tons apiece it was necessary to build special carts to haul them from the railway to the dam, a distance of 60 miles. At the dam, the cableways and derricks already installed by the contractors were strong enough to handle the apparatus.